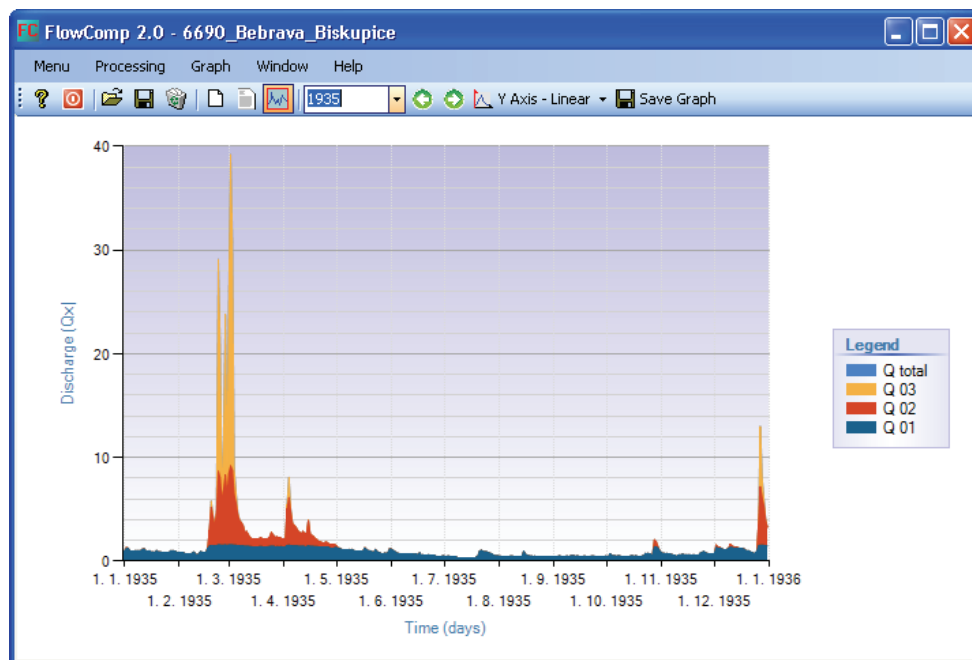# HydroOffice
Software for Water Science

FlowComp 2.0
User's Manual

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2012

Product Name: FlowComp
Version: 2.0
Build: 4
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CONTENTS

1 INTRODUCTION

This manual was created for the use of the FlowComp 2.0 tool (build 4) of HydroOffice 2012 software. The manual describes the functionality and limits of tool usage. After passing the manual, you should be able to use the full functionality of the module.

The basic objective of the tool FlowComp in version 2.0 is the flow separation to individual runoff sub-regimes. Discharge data should be acquired from systematic surface streams discharge measurements or measurements of springs' yields. The program uses a methodical approach created by Malík (2010). FlowComp 2.0 program allows, in comparison with the BFI+ 3.0 module, separation of several runoff sub-regimes. These sub-regimes are separated on the basis of master recession curve analysis. As a first step, for purposes of master recession curve analysis, it is possible to use the tool RC 4.0, which is an integral part of modular software – HydroOffice 2012.

To prepare the input file of time-series values, it is necessary to study the manual – ***How to prepare input data***. This manual briefly describes the way of input data preparation for individual tools. The great advantage of HydroOffice 2012 is that all tools use the same structure of input data. Therefore, it is possible to use data, prepared for one tool, also in other tools.

Individual tools of the HydroOffice 2012 also use the same structure of the graphical user interface, so if you learn how to use one tool, the transition to the other one will be much more simplified.

I hope that this tool can help you in your daily work. For further study, video-tutorials located on the HydroOffice website can be used for help with the tools. In the case a bug in the tool is found, or you have an idea for its improvement, or for any other question, please use the user forums on the site, so that other users can share the solution or proposal. Also, if you know a solution to the problem of another user, please do not hesitate to help him. Your participation on the forums can really help us all in issuing new tools and improving the existing ones.

When using the HydroOffice tools and outputs, please quote them. Proper and correct references can be found on website. After you quoted, please send me a citation to your output to add it to the citation page with the reference to your work site.

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2 MAIN FUNCTIONS

The basic features of the program are listed in the **Menu** (Fig. **1**) or shown with the first buttons in application toolbar. The function **Open Data** is used to import the input data to the program. After selection and entering of the input file, the data are stored in the input data table (Fig. **2**).
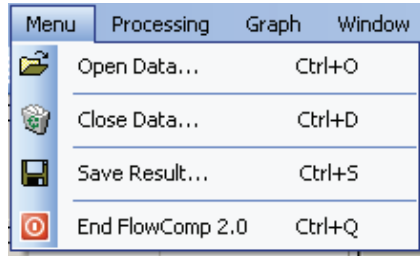

Fig. 1. Basic commands in FlowComp 2.0 tool

If the input file is formatted correctly, the dates of discharge/yield measurements and their values are automatically divided into separate columns. Also, at the end of the table there should not be more than one line of blank fields. If there are several lines of blank fields, it is possible to delete them after their selection and pressing the **Delete** button. Data prepared in the appropriate way can then be used for further processing (will be described later).

In addition to the aforementioned function, also three other functions are found in the menu. Command **Close Data** serves for complete removal of all data in the application. This command clears the input data table, result data table and results on charts. Command **Save Result** is for saving of calculated results. The forms of results will be presented later. The program allows you to save the results into four types of files (*.txt, *.xls, *.doc and *.rtf). Due to difficulties and problems of compatibility between different versions of programs (e.g. MS Office), the results are not really saving to selected file formats (e.g. .xls). It's always basically just a text file (.txt) that is automatically opened and processed in an associated program (like *.txt.xls). The last command **End** terminates the tool.
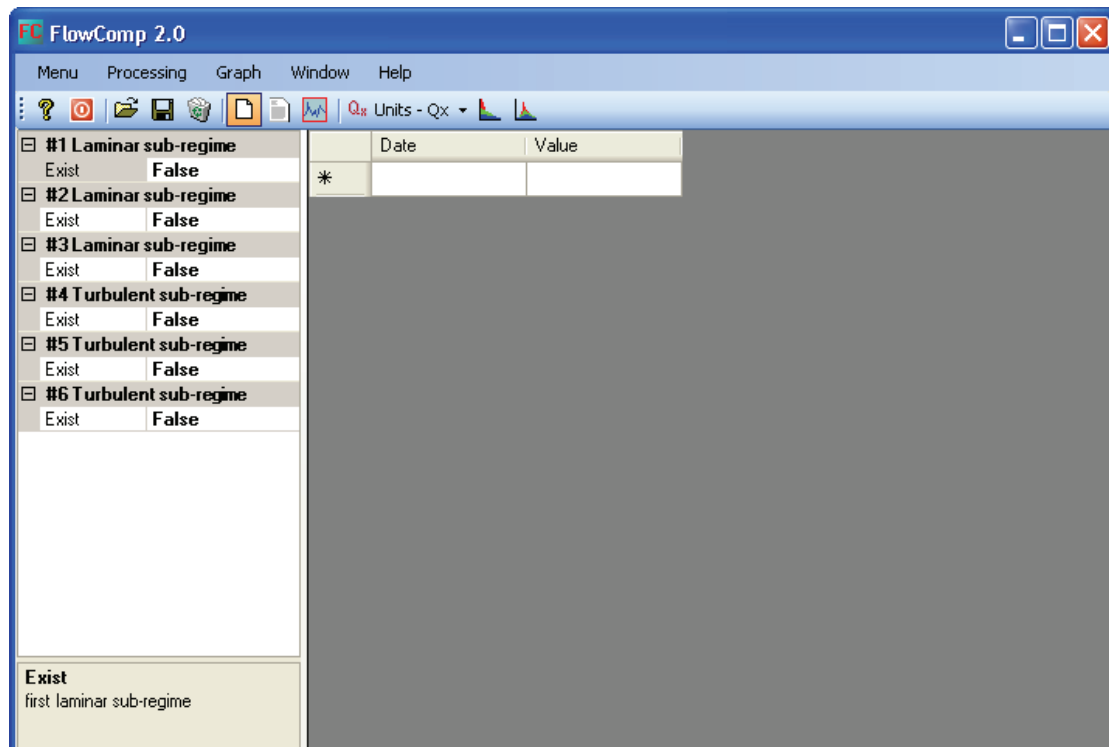

Fig. 2. The input data of FlowComp 2.0 tool

3 BRIEF THEORY

A hydrograph separation technique, using the iterative solution of several exponential and linear equating members, was developed by Malík (2010). This method uses parameters from a set of simple exponential and linear equations. Exponential equations are described by starting discharges Q_0 and recession coefficients α in general; linear equations are described by starting discharges Q_0 and recession coefficients β in general.

The main idea behind the method is based on a simplified understanding of a hydrologic system reality: the same discharge should reflect the same water saturation (piezometric) level in the system. Principles of hydrograph separation based on master recession are demonstrated on Fig. **3**, where for every discharge on the right side of each figure, relevant value on the recession curve is found (by calculation, as described later). Figure shows, how each discharge value can be divided into several sub-regimes, depending on its position on the master recession curve. Hence, the separation method requires detailed recession curve studies of each hydrologic/aquifer system to create really representative master recession curve mathematically described b the same parameters. Every hydrologic system (catchment) or aquifer (spring) can then be described by set of unique (individual) constant values of starting discharges Q_0 and set of unique (individual) recession coefficients (α or β) for each detected flow component (sub-regime).
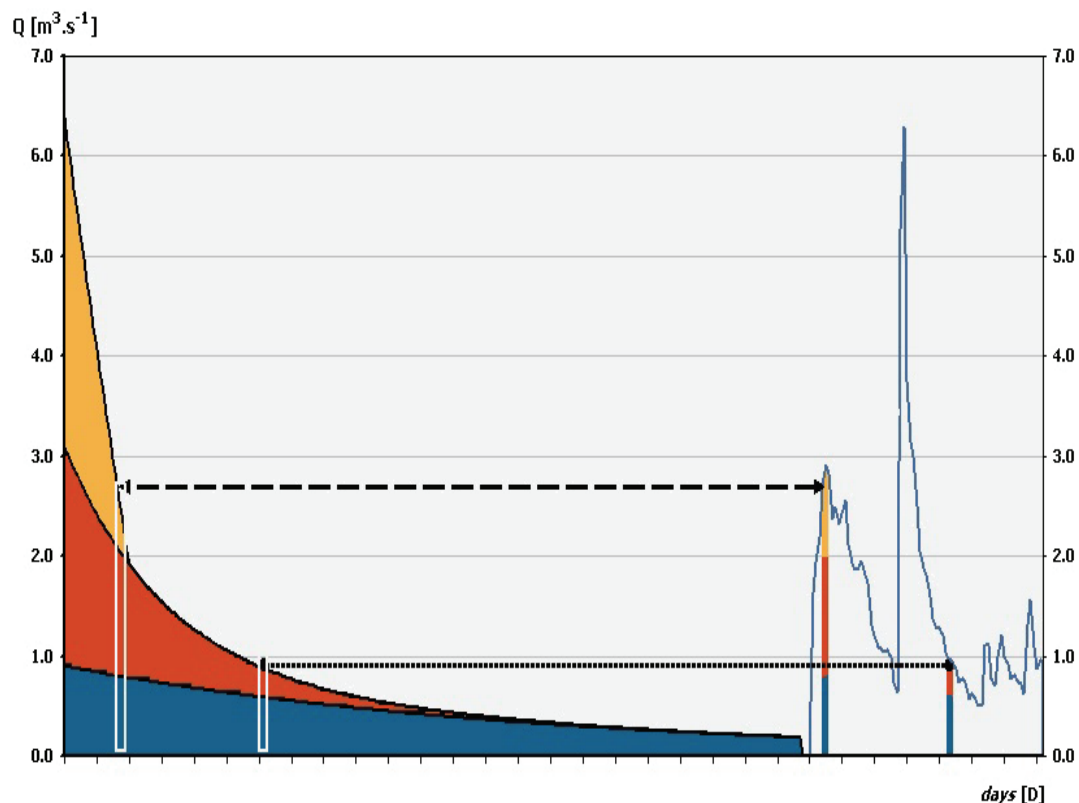

Fig. 3. Principles of hydrograph separation based on the master recession curve

In the process of hydrograph separation into individual flow components, each measured discharge value is understood as a result of superposition of one or several laminar flow components (exponential sub-regimes) and eventually, also turbulent flow components expressed by linear equation members. Every measured discharge value Q_t is then determined just by a representative time t, i.e. theoretical elapsed time

from the overall maximum discharge value Q_{max}. Subsequently, amounts discharged in different flow components (baseflow / groundwater runoff, subsurface runoff, surface runoff) can be calculated. As the exponential equation has no analytical solution, each real discharge value Qt (having its theoretically elapsed time t from the Q_{max} overall maximum discharge value the master recession curve, described by set of pre-described equations) has to be solved by iteration process to obtain partial discharges for each sub-regime. In the iteration process, the two starting time inputs were usually set to be 0 and 1/ α1. Ten iteration procedures are usually sufficient to give result within the discharge reading accuracy. By substitution of the theoretically elapsed time t from absolute Q_{max} of the master recession curve to the partial equation of each individual flow component (sub-regime) we receive the actual partial discharge for the component/sub-regime analysed. To control the calculation, the total discharge has to be the sum of these partial discharges.

The advantage of the use of the master recession curve parameter's hydrograph separation method is that it allows clear solution for every discharge value. However, understanding of hydrologic system functions (the same discharge reflects the same water saturation or piezometric level in the watershed/aquifer) is a rough simplification. In reality, temporary unequal distribution of saturation levels is usual in catchment's quantitative behaviour. Within aquifers, several piezometric levels should exist at least for each saturated system (small fissures, medium fissures, karst conduits), if not for their different parts. Time dependency of these individual piezometric levels then substantially differs one from another. Király (2003) described recession coefficient as a global parameter depending on global configuration of the karst aquifers (also from and extension), and does not recommend its use to for aquifer hydraulic properties calculations. The same author underlines the role of mixing processes and dilution within the aquifer and shows that improperly used chemical or isotopic hydrograph separation methods may lead to invalid inferences regarding the groundwater flow processes. In spite of all, facing practical problems, the discharge data can represent the only quantitative reference value that describes the whole system. Simplified hydrograph separation method, based on proper recession analyses of whole discharge time series in such cases can help to distinguish and quantitatively express basic proportions of individual flow components. This method still may represent a perspective for quantitative referencing of flow components for further interpretations, or at least by its help the diminishing or starting point of individual flow components can be properly quantified.

4 DATA PROCESSING

The first step in the processing is the import of input data using the command **Menu - Open Data**. After the import, it is necessary to adjust the outflow coefficients and parameters in the property grid on the left side of main window (Fig. **2**). In the current FlowComp version, only runoff components (sub-regimes) described by exponential or linear equations can be separated from the discharge time-series. These sub-regimes types can be optionally combined. Each sub-regime is activated by setting the **Exist** parameter to **True**. If the user sets this parameter to **True**, additional cells are shown, where the user defines the respective sub-regime parameters and recession coefficients, obtained from the master recession curve analysis.
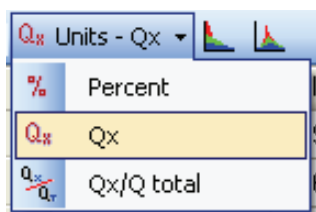
Fig. 4. Settings of units for results

After setting the parameters of all recession sub-regimes equations, the user can set the type of results unit (Fig. **4**). The program can create results' output in three formats. In the first output format, the real discharge values (Q_x) are listed, what means that the results in sub-regimes are displayed as discharges in discharge units (volume per time unit). The second type of output format is displaying of the discharge ratio of the sub-regimes in respect to the total discharge (Q_x / Q_{total}). The last type of results presentation (output format) is to display the previously mentioned results Q_x / Q_{total} ratio in percentage (Q_x / Q_{total} in %). This means that the result is calculated as in the previous example, but the ratio of discharges in individual sub-regimes to the total discharge in the given day is shown in percentage unit.

Fig. 5. Basic processing commands in FlowComp 2.0 module

After setting of the described parameters we can continue by processing of the output data. The program offers two types of analysis (Fig. **5**). The first one is the calculation and visualisation of the master recession curve. Based on the imported data and set parameters (Fig. **6**) the FlowComp module generates the recession curve in both tabular and graphical form.

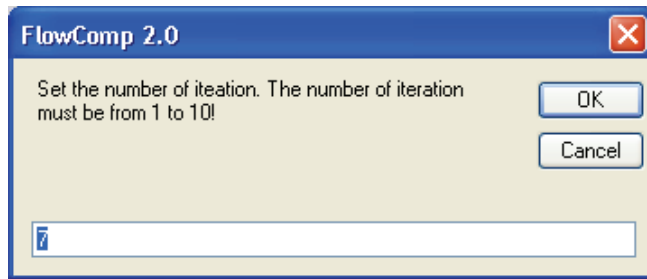**Fig. 6.** Prepared input data before the calculation

Fig. 7. Setting of iteration number for calculations

The second type of analysis is the hydrograph separation into individual runoff sub-regimes in the real time. When executed, the user will have to define the number of iterations in an auxiliary window. The range of optional number of iterations is adjustable from 1 to 10. A predefined number of iterations are 7, as this number is considered to be sufficient for an accurate calculation. An increasing number of iterations increase the time of the algorithm run. Like the previous command, also the second type of analyses generates the results in both tabular and graphical form. The different forms of results are described in the following chapters.

5 TABLE OF RESULTS

In this chapter the tabular results of input data processing will be presented. If the user decides to generate the master recession curve (**F3** command); the table of results will have a structure as shown in Fig. **8**. The first column here defines the successive day of discharge from the discharge recession start. In the case that the sum of initial discharges defined in the "property grid" is lower than the highest measured discharge in the imported time-series (real measurements); the program extrapolates the master recession curve to the maximum documented value of discharge. Then, the first column may contain negative values. The following six columns then contain the calculated discharges in individual sub-regimes. The last column contains the value of the total discharge in all sub-regimes.

Time	Q01	Q02	Q03	Q04	Q05	Q06	Qsum
-1	1.6274	11.9202	340.9806	0	0	0	354.5282
0	1.6	8.4	51	0	0	0	61
1	1.573	5.9194	7.628	0	0	0	15.1204
2	1.5465	4.1713	1.1409	0	0	0	6.8587
3	1.5204	2.9395	0.1706	0	0	0	4.6305
4	1.4948	2.0714	0.0255	0	0	0	3.5917
5	1.4696	1.4597	0.0038	0	0	0	2.9331
6	1.4448	1.0286	0.0006	0	0	0	2.474
7	1.4205	0.7249	0.0001	0	0	0	2.1455
8	1.3965	0.5108	0	0	0	0	1.9073
9	1.373	0.36	0	0	0	0	1.733
10	1.3499	0.2537	0	0	0	0	1.6036
11	1.3271	0.1787	0	0	0	0	1.5058
12	1.3047	0.126	0	0	0	0	1.4307
13	1.2827	0.0888	0	0	0	0	1.3715
14	1.2611	0.0626	0	0	0	0	1.3237

Fig. 8. Tabular presentation of the master recession curve calculation

If the command for sub-regime separation in time was used (**F4** command), the table of results will have structure and character as shown in Fig. **9**.

Fig. 9. Tabular presentation of the results of hydrograph separation into individual flow sub-regimes

The first column of table shown on Fig. **9** contains the real date value from the imported measured discharge time-series. The second column contains values **Outflow Time**. This parameter is defined on the basis of the calculated master recession curve (which was shown in Fig. **8**; the previous tabular results' example - in the first column). These **Outflow Time** values from the table define the time from the absolute start of recession as described by the master recession curve selected. Based on this, algorithm finds the discharge ratio value in the master recession curve and then substitutes the discharge values of individual sub-regimes into the next columns of the table (**Q_{01} - Q_{06}**). In the last column, the values **Q_{SUM}** as total sum of discharges in all sub-regimes are displayed. The calculated values can be exported using the command **Menu - Save Results** (Fig. **1**).

6 GRAPHICAL RESULT / CHARTS

Presented tabular results can be displayed also in graphical form. When using the command **Processing - Recession Curve** (Fig. **5**), the program, in addition to tabular data, generates also a graph as displayed on Fig. **10**. This example shows the master recession curve with three laminar sub-regimes, in a view with logarithmic values of discharges displayed on the Y axes.
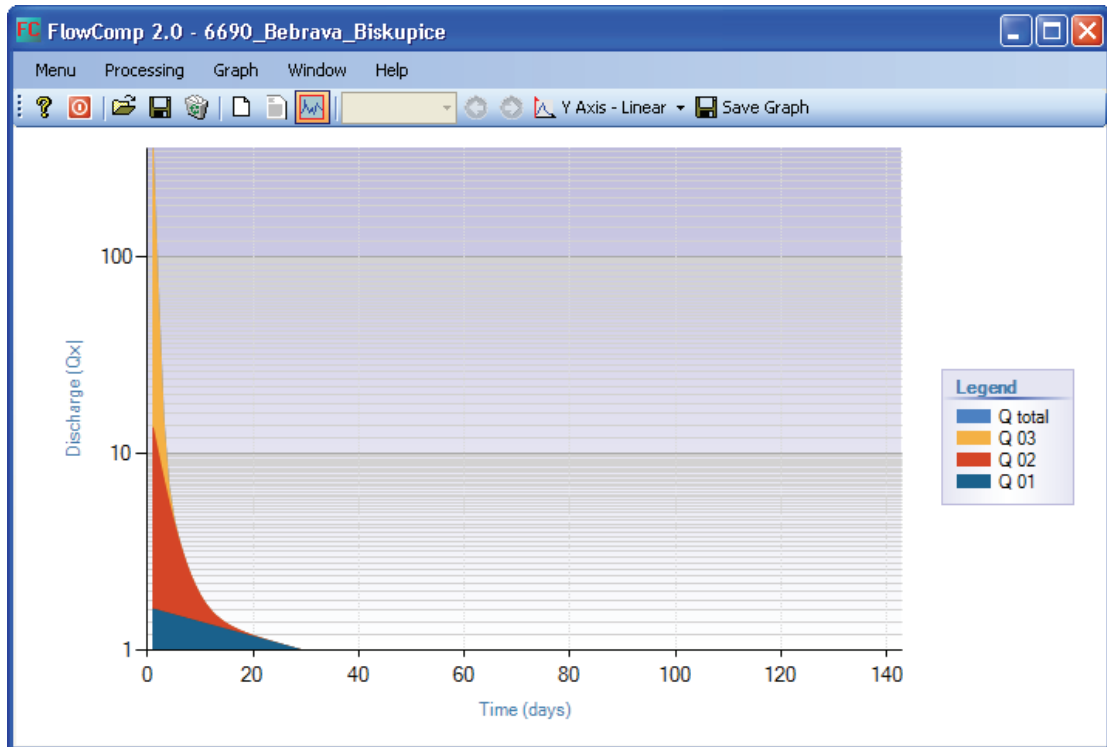
Fig. 10. Graphical representation of calculated recession curve

For the second function (**F4**), an example of the graphical result is shown in the Fig. **11**. This example shows the hydrograph with the course of individual separated sub-regimes within one year. As in the previous example, three laminar runoff sub-regimes (described by exponential equations) were identified and subsequently used for the hydrograph separation. The displayed time unit (year) can be changed using tools in the toolbox. The tools to change the view of Y-axis (linear/logarithmic) are also shown in the toolbox, as well as a function saving the chart as an image file.
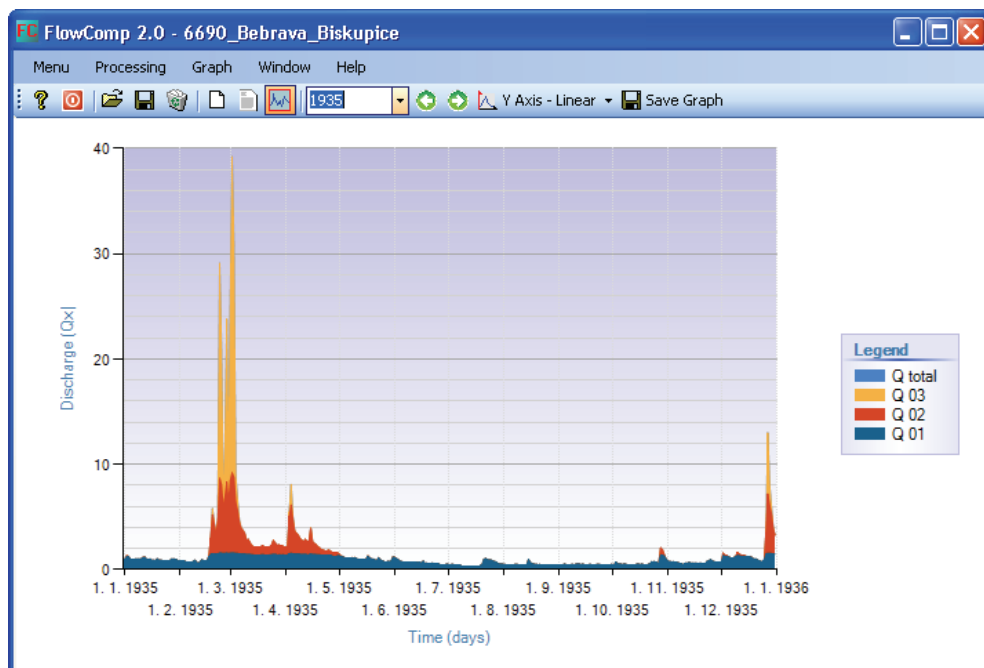

Fig. 11. Graphical representation of the calculated hydrograph separation into 3 sub-regimes identified in the master recession curve
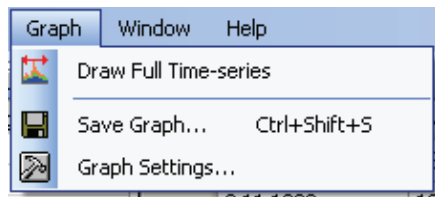
Fig. 12. The menu for results processing graph control

Other tools for chart control can be also found in the **Graph** menu (Fig. **12**). The first command **Draw Full Time-Series** is used to display the results of hydrograph separation for each sub-regime during the duration of the whole imported time series.

The **Graph Settings** function is used for other visual settings of displayed graph. After its launch, the window (Fig. **13**) is displayed, serving to these purposes, where it is possible to change all visual settings of graphs by the use of commends offered.
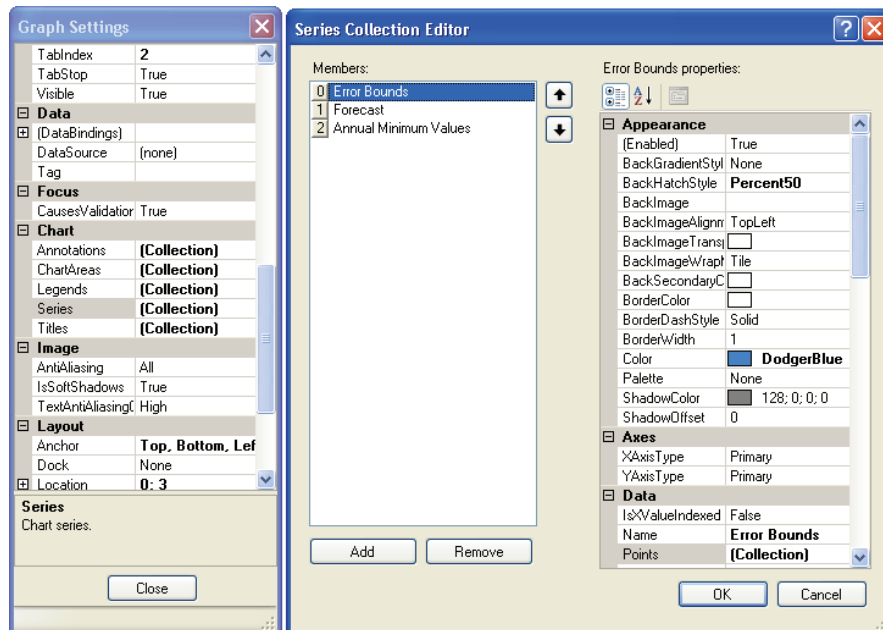

Fig. 13. Tools for visual graph adjusting

7 CONCLUSION

This manual describes the functionality and possible uses of the FlowComp 2.0 module for hydrological and hydrogeological analysis. Module serves for hydrograph separation, using the master recession curve, to separate individual runoff components from the catchment, spring or hydrogeological structure.

Application has several features, described in the text in detail. In the case of any problems with the module, the user's forum on the HydroOffice.org web can be contacted and used. Videotutorials can be used in the further study of the module functionality as well. They can be freely downloaded in the Downloads section.

In the case you might feel any absence of function or feature in the program, please inform me about it in the forum on the web. If you find a bug in the program, I will be grateful for the notification. You can send the relevant information to me either via forum or via my email.

If you managed to successfully use this module, it would be great to cite it in your output. If you do not know how or what to quote, on this page you can find the publications focused to HydroOffice software and its modules. If you already quoted something of HydroOffice project, I'll be happy to receive any feedback or information and also a quote to your output. Together with your reference, I can also add a link to your site on this page of HydroOffice web, to help you with better placement in web searching engines.

8 REFERENCES

Király L (2003) Karstification and Groundwater Flow / Speleogenesis and Evolution of Karst Aquifers. In: Gabrovšek, F. (Ed.). 2002: Evolution of karst: from prekarst to cessation, Zalozba ZRC, Postojna-Ljubljana, pp. 155-190

Malík P (2010) Separácia hydrogramu pomocou parametrov reprezentatívnej výtokovej čiary. [Hydrograph separation into flow components using parameters of the master recession curve; in Slovak with English summary]. Podzemná voda, XVI, 1/2010, Slovenská asociácia hydrogeológov, Bratislava, ISSN 1335-1052, 113-124