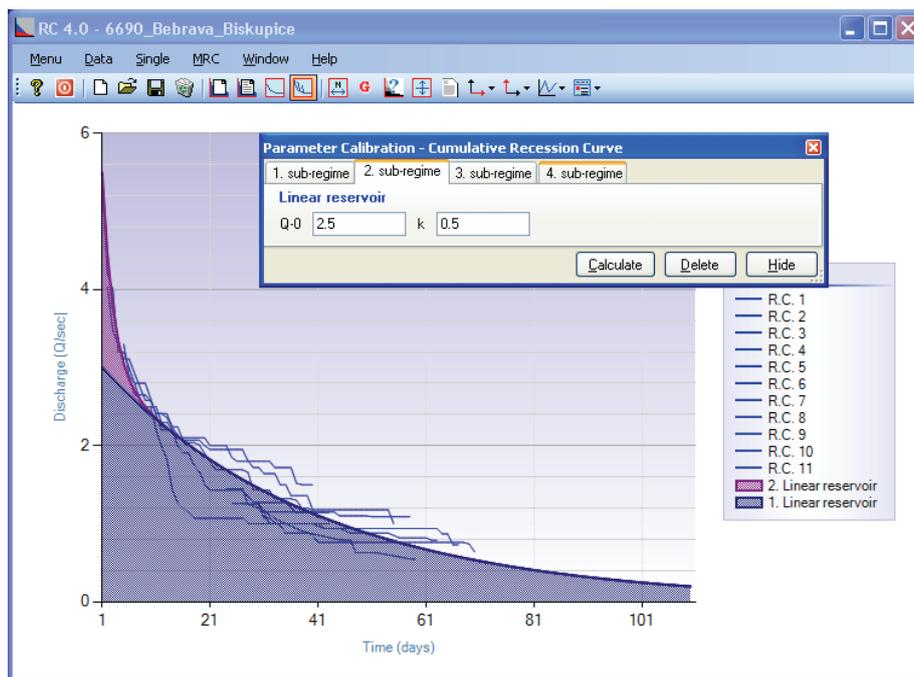


RC 4.0

User's Manual



By Miloš Gregor and Peter Malík

2012

Product Name: RC

Version: 4.0

Build: 12

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1 INTRODUCTION

This manual was created for the use of the RC 4.0 tool (build 12) of the [HydroOffice 2012](#) software. The manual describes the functionality and limits of the tool usage. After reading the manual, you should be able to use the full functionality of the tool.

RC 4.0 tool is used for complex processing and analysis of the recession curves, using various new methods and tools. The program allows analysing individual recession curves or master recession curves. The master recession curves can be created manually or by using an innovative tool that combines strong hybridised genetic algorithm and the methods of artificial immune system. The program also allows the analyses of the superposition of four sub-regimes of discharge, and the 13 most used recession models can be employed.

To prepare the input file of time-series values, it is necessary to study the manual – *How to prepare input data for tool*. 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 a 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 forum 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 forum 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 output to add it to the citation page with the reference to your work site.

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2 MAIN FUNCTIONS

The functionality of this program is broader than of the other tools of HydroOffice 2012. Basic functions of the tool RC 4.0 can be found in **Menu** (Fig. 1).

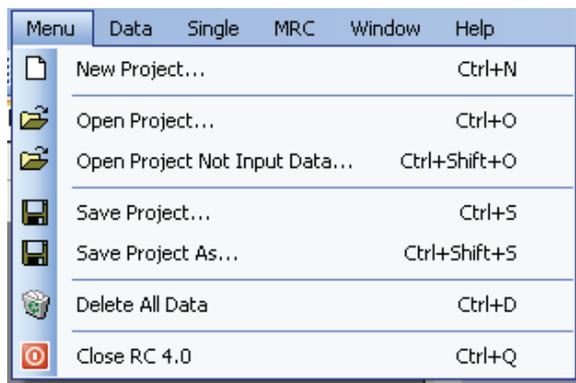


Fig. 1. Basic commands in the RC 4.0 tool

The important advantage of RC 4.0 is that it allows you to store partial results of recession curve processing into a separate file for later continuation of the analysis. These partial results are stored in XML file. To save the results, the commands **Save Project** or **Save Project As** are used. In the case the user wants to open the saved results, he/she can use the function **Open Project**. This file also contains information about the linking to the files of rainfall input data and discharge input data. If the user

had already selected recession curves from the time series measurements of discharge, he/she may use the function **Open Project Not Input Data**, that imports into the program all the partial results, but without the input data files. This function will be performed faster in comparison to the situation when the user also opens the input data. The **New Project** function prepares the program for new processing and **Delete All Data** function clears all data from the program. **Close RC 4.0** function serves for closing the program (Fig. 2).

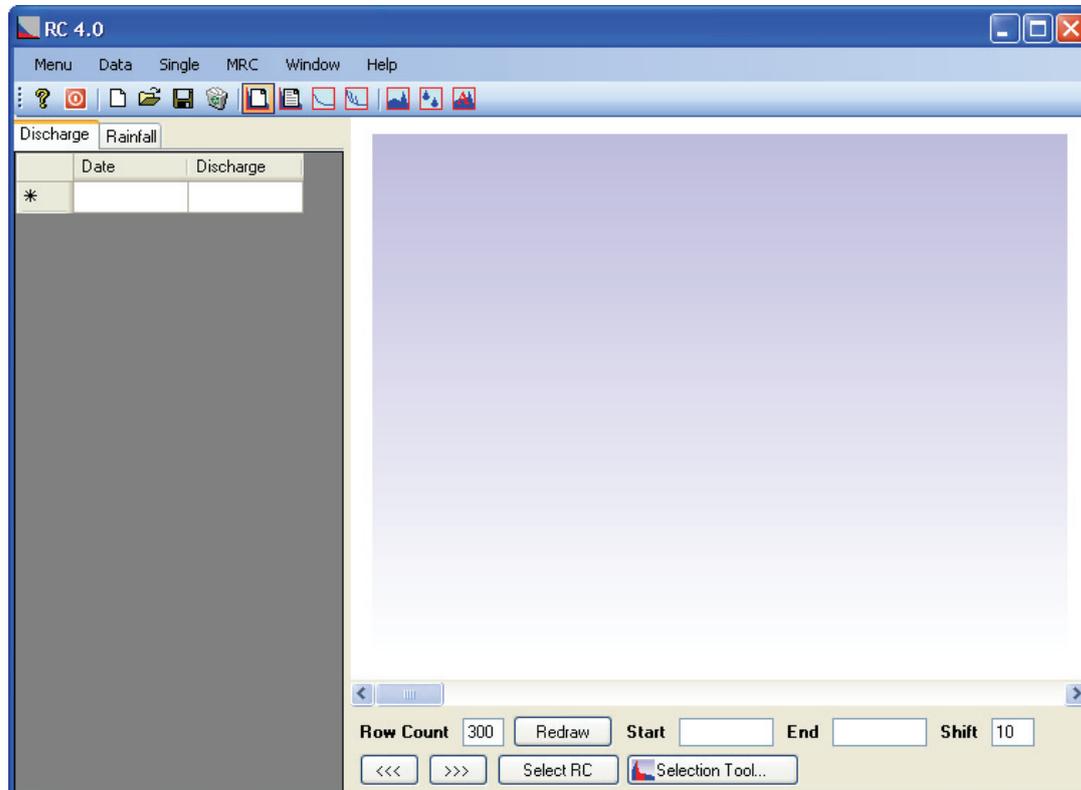


Fig. 2. The main window of RC 4.0 tool

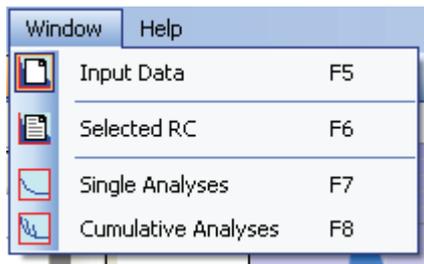


Fig. 3. Commands for switching between main windows

In the main window, all the basic activities in the recession curves analysis are performed. These activities are divided into four parts (processing of data input time-series – selected recession curves processing – analysis of individual recession curves – analysis of the master recession curve). Each of these activities has its own visual interface and for switching between them, functions in the **Window** menu (Fig. 3) are used.

Similarly structured is also the menu in the program, when for processing the input time-series and selected recession curves is used the menu **Data**, for the processing of individual recession curves is used the menu **Single** and for the processing of master recession curve, the functions in the menu **MRC** (Fig. 2) are used.

3 INPUT DATA

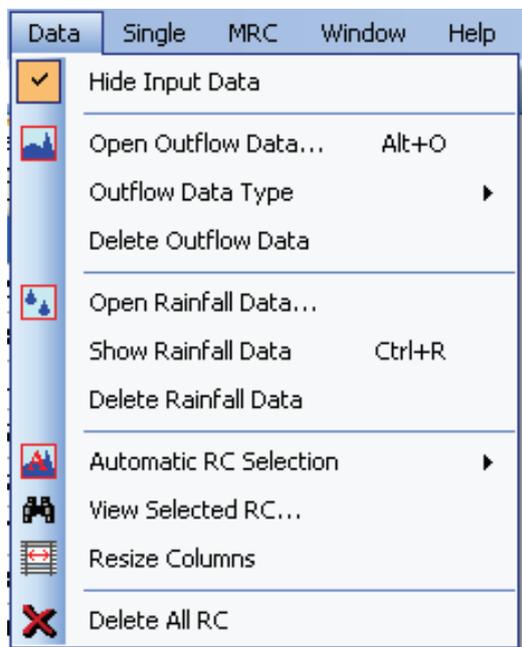


Fig. 4. Functions in Data menu

For processing of the input data and selected recession curves, the functions in the menu **Data** are used. Time-series of river discharge or spring yields can be imported into the program using the **Open Data Outflow** function (Fig. 4). Into the program, both daily and weekly measurements in time-series can be imported. It is necessary to set the observation period (daily / weekly) for the program, as if weekly time series are used, while the program is set for daily observation period type, the results of the recession coefficients analysis are incorrect. It is possible in to set the daily or weekly measurement periods in the menu **Data - Outflow Data Type – Daily / Weekly** (Fig. 4). Deleting the input data is enabled by using the **Delete Outflow Data** function.

In addition to the discharge time-series, time-series of daily precipitation can also be imported into the program. They can be imported using the **Open Rainfall Data** (Fig. 4). **Delete Rainfall Data** function will delete the imported time-series of precipitation.

After successful import of the input data into program, the main window will appear like in the Figure 5. The main window is divided into two parts. In the right part, the imported data of discharge and rainfall are displayed, and in the left part of window these data are displayed in the chart.

If the user wants to see and analyse in one window not only discharges, but also the rainfall data, the second graph of daily precipitation can be displayed using the **Data - Show Rainfall Data** function (Fig. 6).

The main program window will then appear as shown in Figure 6. The advantage of the program is that all the controls in the window are synchronized. This

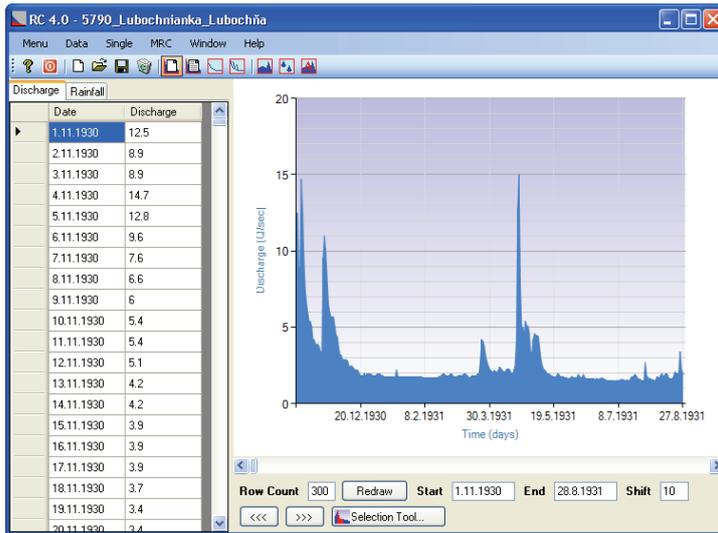


Fig. 5. The main window after successful import of discharge time-series

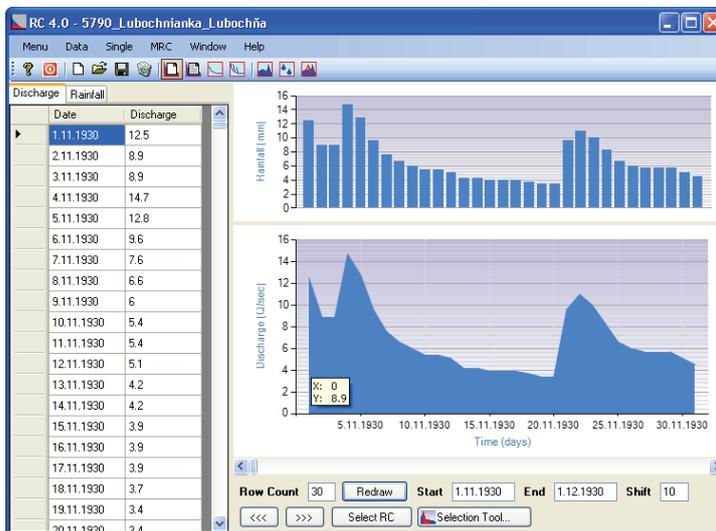


Fig. 6. View on imported discharge and rainfall data

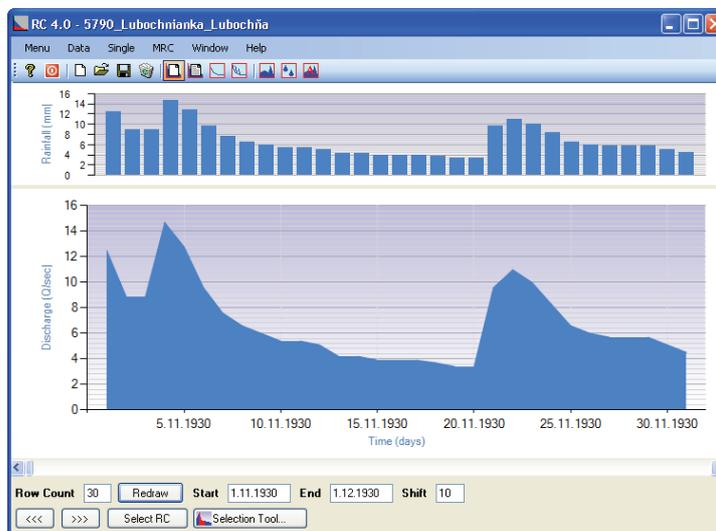


Fig. 7. View of imported discharge and rainfall in the entire application window

means that if we move the selection in the time, than the discharge and rainfall are automatically displayed for the given time in the graph, and input data tables are scrolling at a given row.

If the user wants to display only graphs without tables in the main window, the function **Data - Hide Input Data** (Fig. 4) can be applied. The window will then appear as in Figure 7.

The user may move in the timeline of the imported data in three ways. The first is to click on the selected cell in the discharge table. When the user clicks on a cell, the program defines this day as the first day in the chart. The **Row Count** parameter window below the chart finds the number of rows for drawing and plots these values (Fig. 8). If the user imports also the rainfall (precipitation) values into the program, and the rainfall graph is displayed, the same period in the rainfall table is automatically selected and the adequate values appear on the top chart. If such values are not found, nothing is plotted on the upper graph.

The second way for shifting of plotted values on the time axes of the graph is the button “<<<” used to move in the backwards direction and button “>>>” used to move in a forward

direction in the time. The program then shows the period length as values of the **Row Count** parameter and the shift in time is defined by parameter **Shift** (Fig. 8).

The last and fastest way of shifting in time is using of the horizontal scrollbar below the chart of discharge (Fig. 8). By this shift, displayed values automatically move within the period of imported range of discharge time-series.

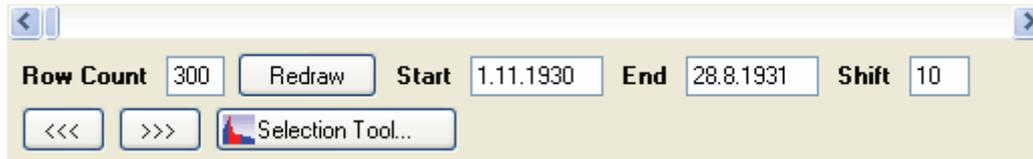


Fig. 8. Tools for input data visualization and recession curves selection

The parameters **Start** and **End** define the start and end of the period, drawing in chart. Button **Redraw** is used to redraw the graph in the case when the user changed the **Row Count** parameter.

4 RECESSION CURVES THEORY

Many papers and reports were already written to describe and discuss the recession curves analysis. One of them is also the paper by Tallaksen (1995), which served as a pattern for preparation of this chapter. For further studies, this paper is suggested, together with the works cited in this manual.

Recession analysis is a well-known tool in hydrological analysis. Its application, however, poses many methodical questions, and throughout the literature numerous solutions have been sought. The quantification of the recession curve involves the selection of an analytical expression, derivation of a characteristic recession and optimization of the recession parameters. A major problem is the high variability encountered in the recession behaviour of individual segments. The segments represent different stages in the outflow process, and a physically based short-term or seasonal influence on the recession rate adds to the problem of deriving a characteristic recession. This paper discusses these elements of recession analysis and reviews different ways of characterizing the baseflow recession rate (Tallaksen 1995).

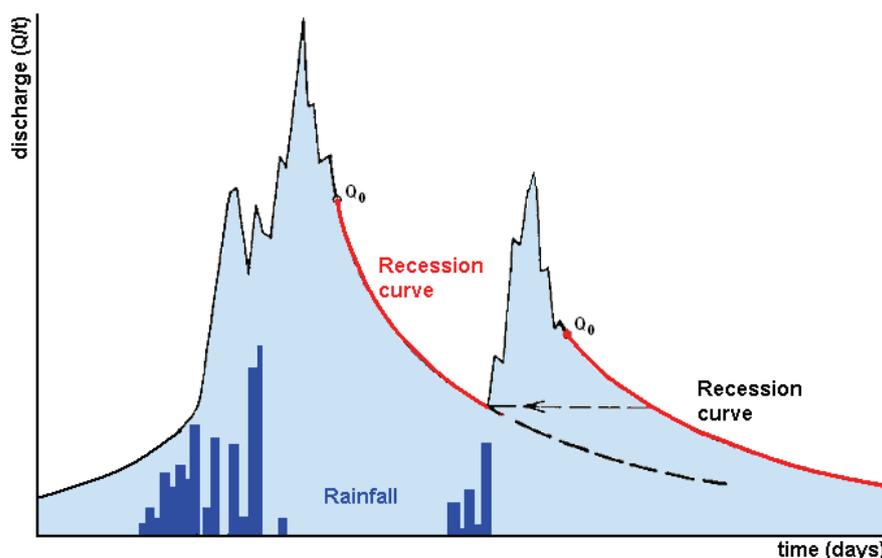


Fig. 9. Definition of recession curves (Kullman 1990, enhanced)

During dry weather, water stored in the catchment is removed by soil- and groundwater drainage and by evapotranspiration. These processes proceed at different rates in time and space, and are not readily quantified. The gradual depletion of discharge during periods with little or no precipitation constitutes the drainage or recession rate, graphically presented as the recession curve (fig. 9).

For analysis of recession curves, many recession functions are used. The most common are included in Table 1.

Table 1. Recession functions, used in RC 4.0

Conceptual model	Recession Function	Storage types/ Comments
Linear reservoir (Boussinesq 1877; Maillet 1905)	$Q = Q_0 e^{-kt}$	General storage Linearised Duperit-Boussinesq equation Approximation for short time periods
Horton double exponential model (Horton 1933)	$Q = Q_0 e^{-\alpha_2 t^m}$	General storage Transformation of linear reservoir model
Model 3 (Coutagne 1948)	$Q = Q_0 (1 + (n-1)\alpha_0 t)^{n(1-n)}$	Karstic aquifers
Model 4 (Padilla et al. 1994)	$Q = (Q_0 - Q_c)(1 + (n-1)\alpha_0 t)^{n(1-n)}$	Karstic aquifers Q_c is discharge from low-transmissivity components of karst
Channel Bank Storage (Cooper and Rorabaugh 1963)	$Q = \alpha e^{-k.t}$	Channel banks Variant of linear reservoir. Also used to model evapotranspirative losses
Exponential reservoir	$Q = Q_0 / (1 + \phi Q_0 . t)$	Throughflow in soil Hydraulic conductivity assumed to exponentially decrease with depth
Power-law reservoir (Brutsaert and Nieber 1977; Hall 1968)	$Q = Q_0 / (1 + \mu t)^p$ $p = \beta / (1 - \beta)$ $\mu = \alpha^{(1/\beta)} (\beta - 1) Q_0^{(\beta-1)\beta}$	Springs and unconfined aquifers ($p = -$ 2), Soil moisture Recessions modelled using $p \approx 1,67$; (Wittenberg 1994)
Duperit-Boussinesq aquifer storage (Boussinesq 1904)	$Q = Q_0 (1 + \alpha_3 t)^{-2}$	Shallow unconfined aquifer Special case of power-law reservoir for Duperit-Boussinesq aquifer model
Depression storage Detention storage (Griffiths Clausen, 1997)	$Q = \alpha_1 / (1 + \alpha_2 t)^3$	Surface depressions such as lakes and wetlands Variant of power-law reservoir
Cavern storage (Griffiths Clausen, 1997)	$Q = \alpha_1 - \alpha_2 t$	Underground caverns in karst terrain
Hyperbola reservoir (Toebe Strang, 1964)	$Q = \alpha_1 t^{-\nu} + b$	Ice melt, lakes
Constant reservoir (Toebe Strang, 1964)	$Q = \alpha$	Permanent snow and ice pack, large groundwater storages Constant stream flow over time period
Turbulent model (Kullman 1990)	$Q = Q_0 (1 - \beta t)$	Karstic aquifers
Hyperbolic model (Kovács 2003)	$Q = Q_0 / (1 + \alpha t)^n$	Karstic aquifers

Q – discharge
t – time since beginning of recession
Q₀ – discharge for t = 0
k, n, m, α, β, γ, φ – parameters to be determined by calibration

The recession functions, described in Table 1, are already used within the RC 4.0 tool. These recession functions can be used optionally, while it is possible to create the superposition, which will be explained later. It is also possible to use these

recession functions in the analysis of individual recession curves, as well as the analysis of master recession curves.

In a humid climate, rainfall frequently interrupts the recession period. As a result, each discharge series produces a series of recession segments of varying durations. Several methods have evolved to construct a master recession curve from the selection of shorter recessions. A major problem is the high variability encountered in the recession behaviour of individual segments. The segments represent different stages in the outflow process, and a physically based short-term or seasonal variation in the recession behaviour adds to the problem of deriving a characteristic recession. The master recession methods try to overcome the problem by constructing a mean recession curve. Information on the recession variability is then lost. If the variability within the catchment is of the same order as between catchment variation, care should be taken when comparing master recession curves. The variability can be estimated by obtaining a quantitative expression for each segment (Tallaksen 1995).

Traditionally, graphical methods have been used to construct a master recession curve. The individual recession segments are plotted and adjusted horizontally until they overlap in the main parts. The master recession curve is then constructed as the mean line by best eye fit through the set of common lines. This method permits a visual control of irregularities in the recession curve, but often telescopes or contracts the true recession.

This method is part of the RC 4.0 program. Besides it, there are many other possibilities for creation of master recession curves. Program RC in version 4.0 brings another new method of automated master recession curves assembly. For this purpose, a combination of strong hybridised genetic algorithm method and method of artificial immune system is applied. This method is somehow difficult to understand, but it has a number of crucial advantages over the other methods used for master recession curves creation. Setting up and running of this method is described in a separate chapter of this manual and its theoretical description is published in a separate paper (Gregor and Malík 2012).

5 SELECTION OF RECESSION CURVES

On the Figure 8, the functionality of **Selection Tool** button was not entirely explained. This button is used for manual selection of recession curves from the discharges plotted on the graph. It is also possible to select the recession curves using two other tools (Fig. 10).

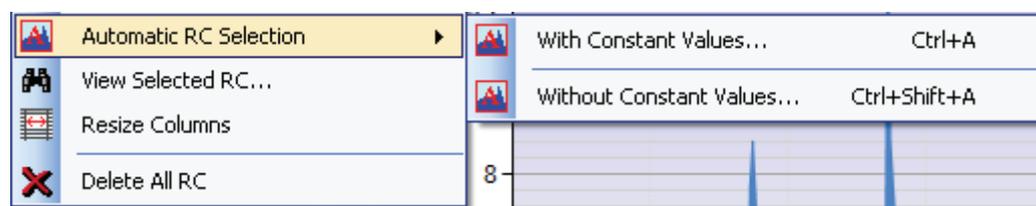


Fig. 10. Tools for automatic selection of recession curves from discharge time-series

The functions **Automatic RC Selection** serves for automatic selection of recession curves from the time-series. After the start, the user enters a minimum number of days (or weeks) in which the river/spring discharge should be in decrease. If the user runs the function **With Constant Values (Ctrl + A)** program also includes

the steady-flow periods into the analyses and further selection. If the user selects the **Without Constant Values** function, the program selects only those periods with decreasing discharge (where following discharge is lower than previous), while days with constant discharge values are excluded. Maximum number of selected curves is 265. Maximum length of the recession curves is not limited. If the program exceeds this limit, further search is terminated and user is notified about the date at which the search was terminated.

In the selection process of recession curves, however, the most recommended process (which I most frequently prefer to use) is the manual search for recession curves, as the aforementioned algorithms cannot include analyse of precipitation influence on the final selected recession curves yet. Therefore, if during the movement of the timeline, watching the hydrograph I find in the chart a “well-shaped” recession curve, I run a support tool for selecting by button **Selection Tool** (Fig. 8). A result is than shown in the window similar to that on the Figure 11.

In the chart, the same discharge data as in the main window will be shown, but below the graph you will find two sliders. By applying these, the user defines the beginning and end of the selected recession curve. The selection is visually changed on the hydrograph section, and the user immediately sees also the selected period of time-series.

After selecting the intended recession curve, it can be exported using the **Apply** button. Program then separates out these data by special internal marking, and the user then returns to the main window, where he/she may proceed another recession curves selection.

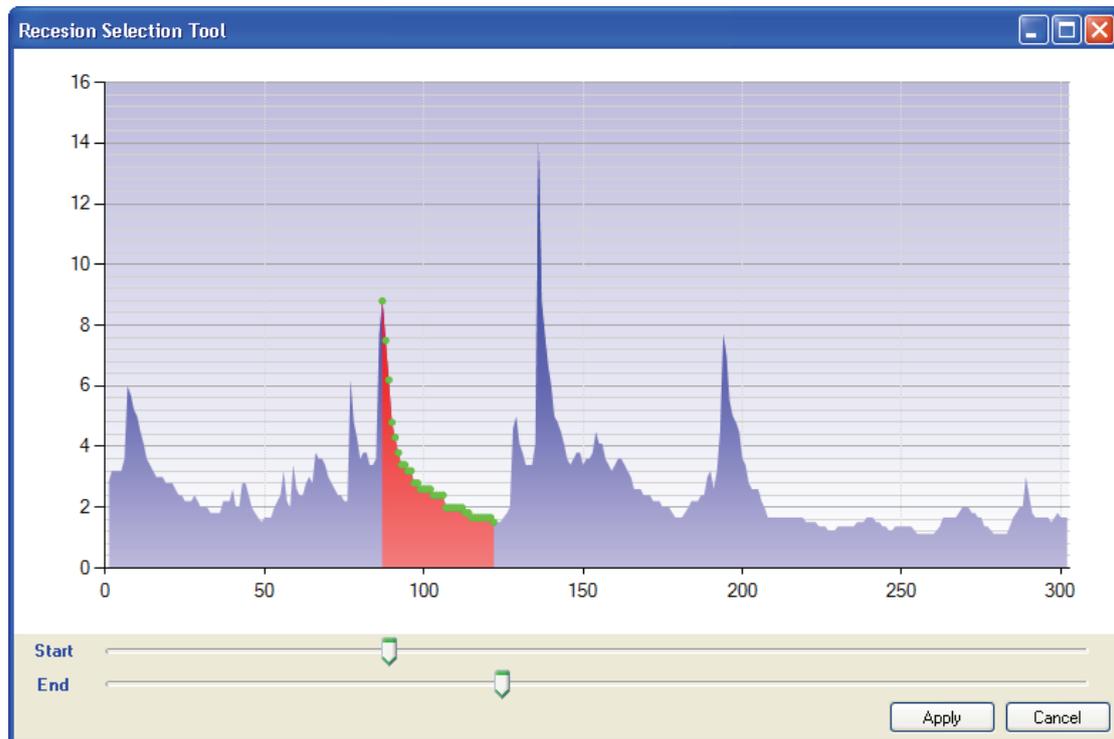


Fig. 11. The window for manual selection of recession curve

6 RECESSON CURVES PROCESSING

In this chapter prior to the main analysis of recession curve parameters and coefficients, options of analysis and processing of selected recession curves in the program will be discussed. During the process of recession curves’ selection, using

either automatic or manual functions, the results are stored within two tables in the second part of the main window (Fig. 12).

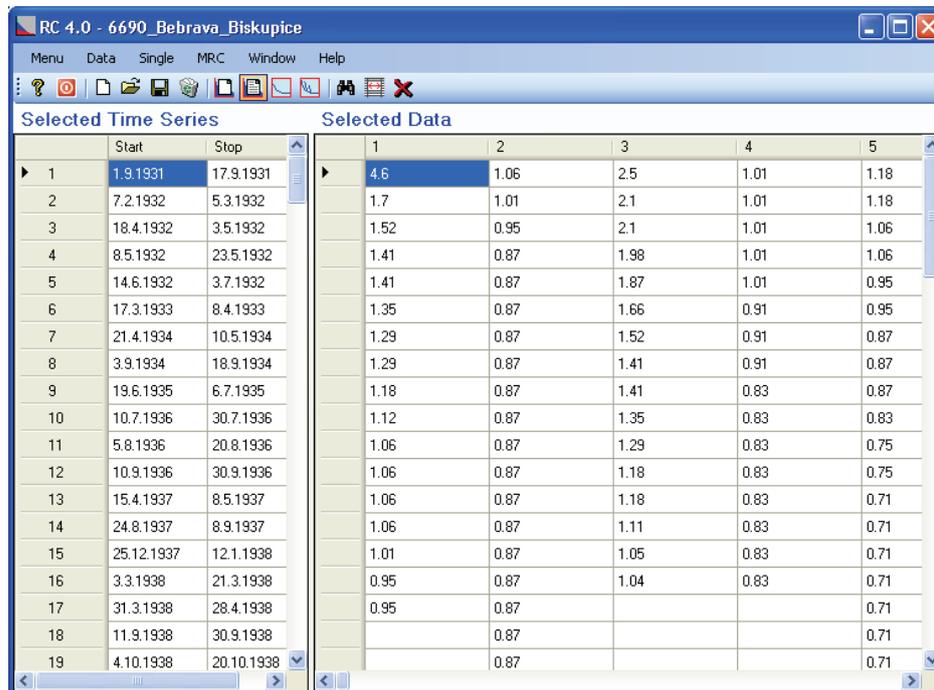


Fig. 12. Window showing already selected recession curves

In the left table of the Figure 12, the starting member (date) and the end date of each selected recession curve are defined. In the right table, selected data in defined periods are vertically displayed. These tables are dynamically interconnected, and if you click at selected cell in the left table, its value is automatically scrolled in the right table.

In the menu **Data** three functions for these tables are defined (Fig. 4). **Delete All RC** function deletes all the selected recession curves. **Resize Columns** command automatically reduces the width of columns in the right table. The last and the most important function is **View Selected RC** (Fig. 13).

By the use of this tool, users can graphically analyse, edit or delete the selected recession curves. If the user clicks on a selected row in the left table, in the chart on the right part, the selected recession curve will be immediately displayed. The column **Number** contains the assigned serial number of the recession curve. In the column **Use** the user can set the use of that recession curve in further analysis (not selected means not taking the selected curve into account during further processing). If this parameter is set to False, and user clicks on the **Apply** button, the respective recession curve is deleted from the tables in the main window. One should note that all the original time-series data remain untouched, and only the selection disappears from the file.

The **Show Data** button, placed to the left from the Apply button, serves for displaying of the discharge time-series values of the selected recession curve. After pressing this button, the data appear on the right part of the window (Fig. 14).

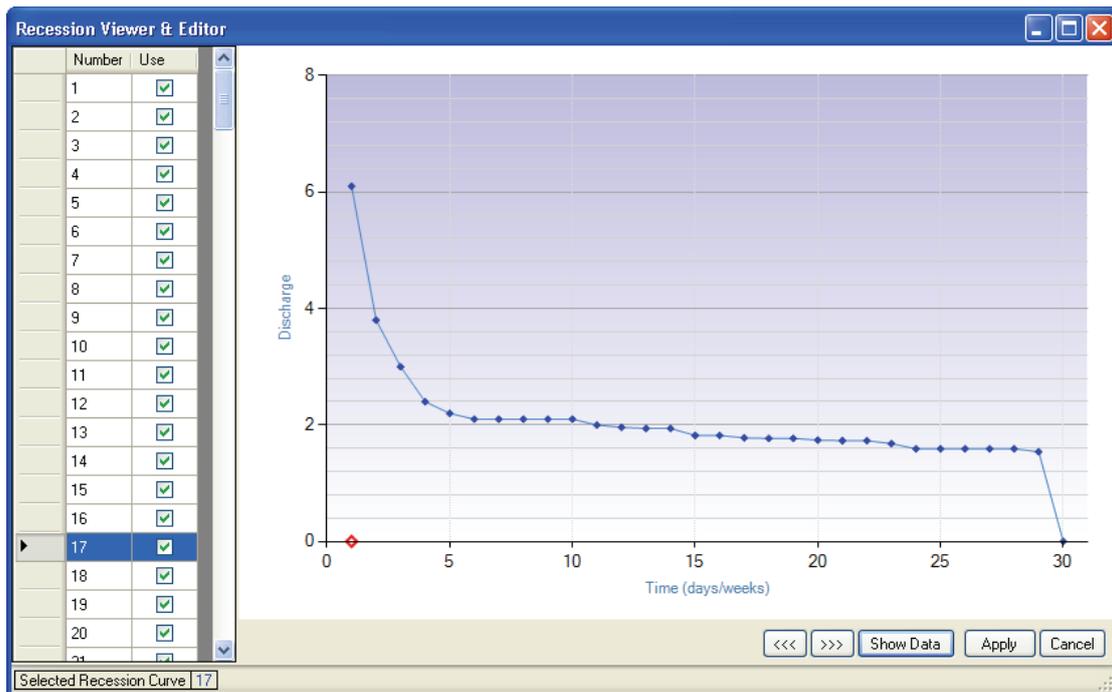


Fig. 13. The tool for selected recession curves editing

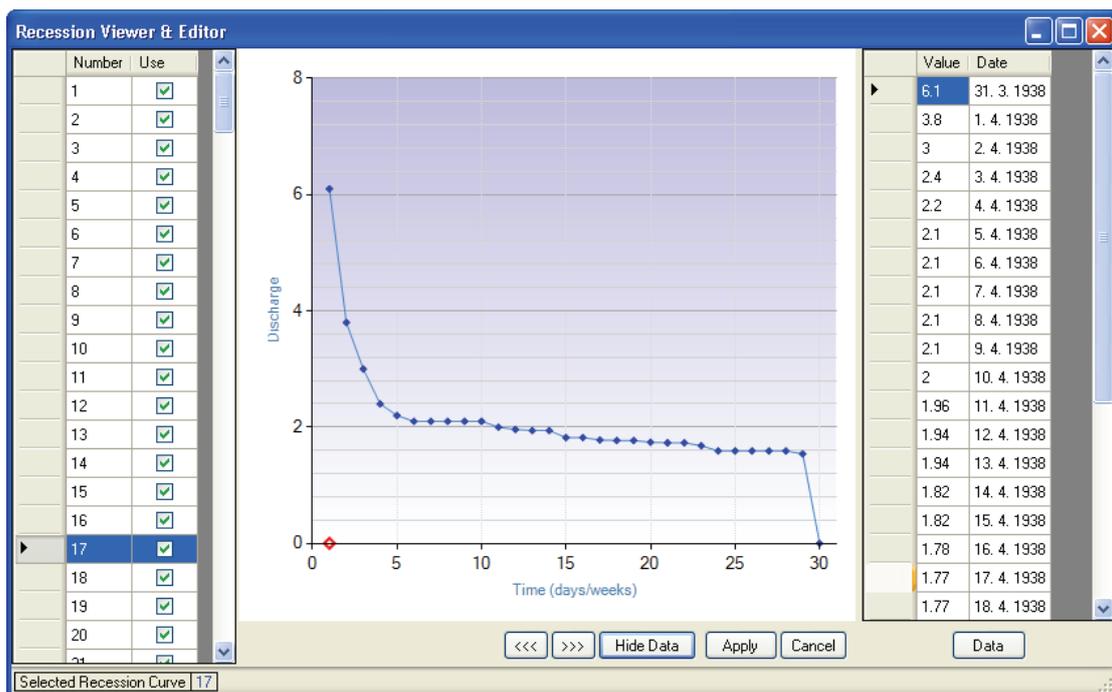


Fig. 14. View of discharges of selected recession curve

Similar to the main window, all the control elements are synchronized. If user select next recession curve, the graph is automatically redrawn and also the discharge values in the right table are changed. Highlighting of the selected value in the chart is possible just by clicking on it in the discharge table (right part of Fig. 15). The respective element is then highlighted by red border around the point on the chart (Fig. 15).

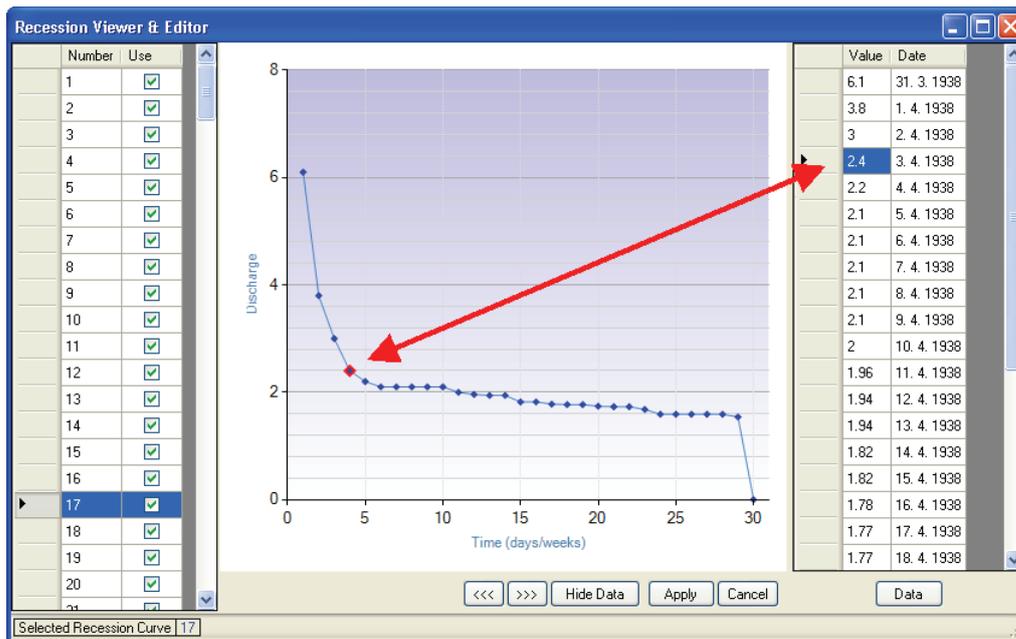


Fig. 15. Highlighting the selected value from table into the chart

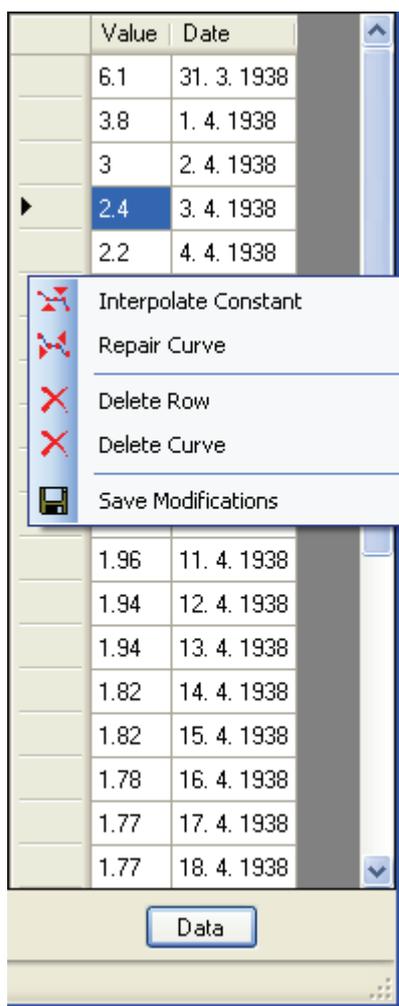


Fig. 16. Automatic modifications of the recession curve values

In addition to the basic plotting of selected recession curves, these curves can be adjusted / edited directly in the table. These adjustments can be done either manually or by automated functions (**Fig. 16**).

The list of functions can be displayed by clicking the right mouse button in table area or by the button **Data** in the main window. The user can manually edit and delete values directly in the table, and these changes are automatically displayed on the chart. For automatic adjustment, 5 functions can be applied. **Delete Row** function allows deletion of the selected row. Function **Delete Curve** serves to delete the entire recession curve.

The function **Interpolate Constant** is used for linear interpolation of the values in the cases when the recession curve contain several periods with the constant discharge, what may occur in the cases when the change of discharge in time is smaller than the accuracy of measurements (e.g. coarse resolution of reading during manual gauging)..

Repair Curve function is used for deleting of several consecutive constant values in the recession curve. By the use of this function, resulting new recession curve is reduced in the number of constant values.

The examples of recession curve modification, using the last two functions are shown in Figure 17. After adjustments of the selected recession curve, it is important save these modifications. Saving of changes is performed by the **Save Modifications**

command (Fig. 16). One should also note that all the original time-series data remain untouched, and only the selected recession curves' data are modified in a separate file.

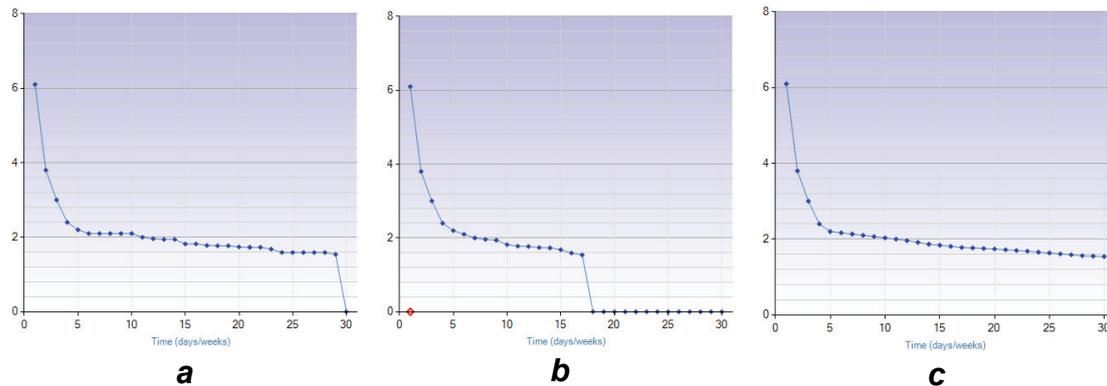


Fig. 17. Automatic adjustment of a recession curve with constant values (a – unmodified recession curve – the original; b – curve after deleting of constant values by the Repair Curve function; c – recession curve with interpolated discharge – interpolation for constant time periods)

If the user wishes to end the modification procedure of the recession curves, these changes can be applied then to data in the main window by the use of the **Apply** button below the chart. The **Apply** button that accepts and applies all the edited data and closes the recession curves processing window. If the user does not want to use adjustments, for closing the window and not saving the modification just click the **Cancel** button.

7 ANALYSIS OF INDIVIDUAL RECESSION CURVES

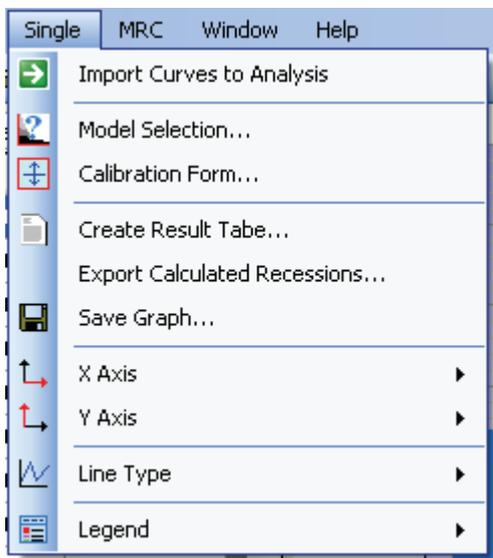


Fig. 18. The tools and functions for analysis of individual recession curves

As it was already mentioned in the introduction, the program allows analyzes of individual recession curves. The window for this analysis can be reached through the menu **Window - Single Analyses**. All tools and functions for these analyses are located in the menu **Single** (Fig. 18).

Before the entire analysis, we need to import all selected recession curves into this section by using the function **Single - Import Curves to Analysis**. This section is separated from the previous one as the user can change the choices of selected recession curves for either individual analysis or for the analysis of master recession curve from assembled recession curves. For individual recession curves analyses, they can be processed after the import. The next step contains the selection of the recession model. This step sets the type (mathematical description) of the recession model for all interpreted recession curves. The recession model is to be set in the second window that is displayed by the function **Single - Model Selection** (Fig. 19).

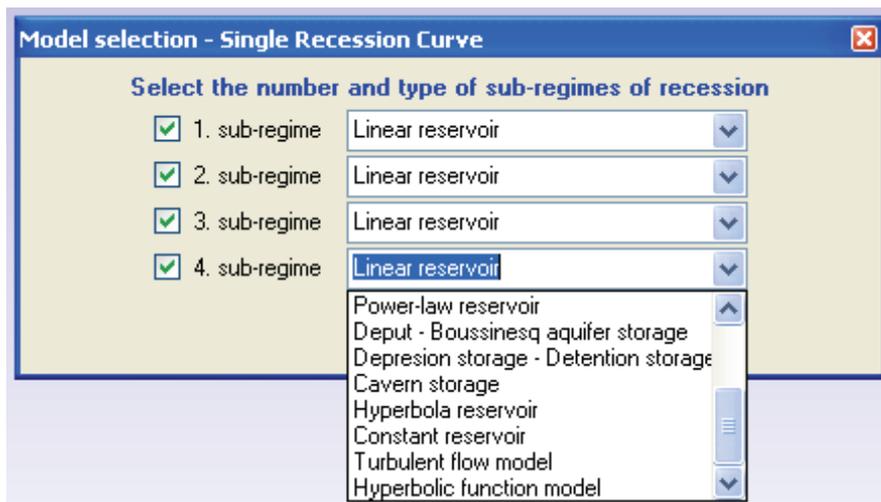


Fig. 19. Setting of the recession model types (mathematical description) for individual sub-regimes before the analysis of individual recession curves

In this window, one can set the number and types of individual discharge recession sub-regime models according to Table 1. For one recession curve, 1 to 4 sub-regimes can be set to form the complete recession regime. These sub-regimes can be activated, if required, by the use of checkboxes. The selected sub-regime type is set by combo box, where the desired recession model (type) is chosen from the pre-selected possibilities. After defining the number and type of all sub-regimes, the selection is confirmed by clicking on the **OK** button.

If the recession curves are already imported and sub-regimes types (model) are set, we can focus on the main analyses of individual recession curves. For this analysis, another auxiliary window is used, that will appear after choosing the function **Single - Calibration Form** (Fig. 18). This window is described on Figure 20.

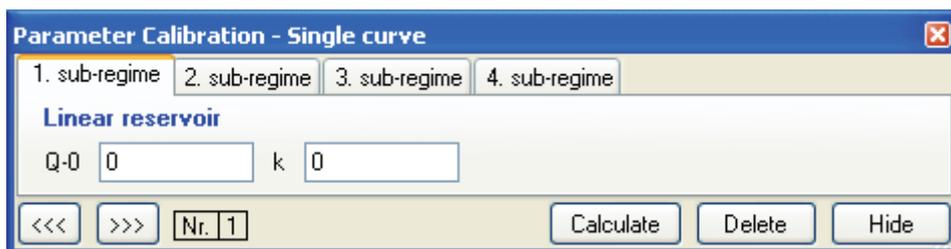


Fig. 20. Auxiliary tool for analysis of individual recession curves

The individual recession curves analytical tool consists of a larger upper part and smaller bottom part. Larger upper part consists of markers where each marker represents an individual recession sub-regime. The content of these markers will vary, depending on the settings of the recession model, which had been previously introduced. For each sub-regime, starting parameters and recession coefficients should be set in this window. Our task is to set these values in the way that the delivery line, calculated by the use of these parameters, will fit the real (measured) data. After setting the parameters, we can depict the measured and calculated recession curve using the **Calculate** button (Fig. 20). To depict the next recession curves, we use the buttons “<<<” and “>>>”. Calibrated parameters and coefficients

are automatically saved, which means that if we choose other recession curve by the buttons presented, not only the measured recession curves, but also the calculated ones are depicted. If the user wants to clear all the results, the **Delete** button can be applied. An example of calibrated recession coefficients is shown on Figure 21.

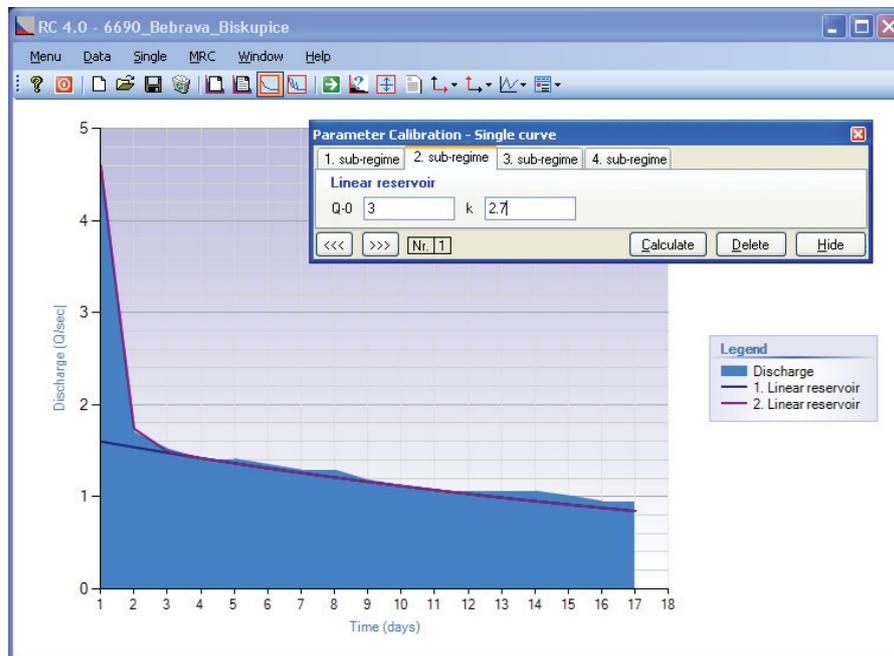


Fig. 21. Calibration of individual recession curves

The blue area is used for the measured data of the selected recession curve and lines correspond to the calculated recession curve values. From various types of individual recession curves analyses results, the program can export several data formats. The first possibility is to export the generated chart in a graphical format. The program enables export of graphical result into six types of graphic formats. To export the graph itself, a **Single - Save Graph** (Fig. 18) function can be applied. It is also possible to export the program results in tabular forms (Fig. 21).

In tabular formats, the export can be performed for two types of individual recession curves analyses results (Fig. 21). In the first tabular format, the values which were depicted on a chart as the calculated results of the selected individual recession curve, are exported. This can be performed by the use of the command **Single - Export Calculated Recession**. This function generates a table containing the values of measured discharge and calculated discharges in each sub-regime, together with their summation, for every day of the selected recession (upper part of the Fig. 21). The second function – **Single - Create Result Table** - generates a comprehensive table of results gathered from all individual recession curves analyses. This table contains results for each recession curve, what means: the date of beginning and date of the end of recession curve, recession duration in days, number and types of recession sub-regimes and the values of recession parameters and coefficients. These results can be exported in separate windows into the four file types.

Other functions in the menu **Single** serve to perform the visual changes on chart. Using these functions, the user can set the type of displayed axis on a chart (linear / logarithmic), it is also possible to show or to hide the legend and to set a smoothing for data series depicted on a chart. In addition, two functions can be displayed by clicking the right mouse button on a chart (Fig. 22). The first (upper one) allows the

export of the chart and the second provides comprehensive tools for visual adjusting of graph. Using this tool (**Graph Settings**), practically everything can be visually configured on a chart.

Table Results

	Date	Recession Curve Data	Calculated Subregime 1	Calculated Subregime 2	Calculated SUM
▶	1. 9. 1931	4.6	1.60E+00	3.00E+00	4.60E+00
	2. 9. 1931	1.7	1.54E+00	2.02E-01	1.74E+00
	3. 9. 1931	1.52	1.48E+00	1.35E-02	1.49E+00
	4. 9. 1931	1.41	1.42E+00	9.11E-04	1.42E+00
	5. 9. 1931	1.41	1.36E+00	6.12E-05	1.36E+00
	6. 9. 1931	1.35	1.31E+00	4.11E-06	1.31E+00
	7. 9. 1931	1.29	1.26E+00	2.76E-07	1.26E+00
	8. 9. 1931	1.29	1.21E+00	1.86E-08	1.21E+00
	9. 9. 1931	1.18	1.16E+00	1.25E-09	1.16E+00
	10. 9. 1931	1.12	1.12E+00	8.39E-11	1.12E+00
	11. 9. 1931	1.06	1.07E+00	5.64E-12	1.07E+00
	12. 9. 1931	1.06	1.03E+00	3.79E-13	1.03E+00
	13. 9. 1931	1.06	9.90E-01	2.54E-14	9.90E-01
	14. 9. 1931	1.06	9.51E-01	1.67E-15	9.51E-01
	15. 9. 1931	1.01	9.14E-01	1.11E-16	9.14E-01
	16. 9. 1931	0.95	8.78E-01	0.00E+00	8.78E-01
	17. 9. 1931	0.95	8.44E-01	0.00E+00	8.44E-01
*					

Save Close

Result Table

Nr.	Start	End	Days	1.subregime	Q_0	k	2.subregime	Q_0	k
1	1. 9. 1931	17. 9. 1931	16	Linear reservoir	1.6	0.04	Linear reservoir	3	2.7
2	7. 2. 1932	5. 3. 1932	27	Linear reservoir			Linear reservoir		
3	18. 4. 1932	3. 5. 1932	15	Linear reservoir			Linear reservoir		
4	8. 5. 1932	23. 5. 1932	15	Linear reservoir			Linear reservoir		
▶	14. 6. 1932	3. 7. 1932	19	Linear reservoir			Linear reservoir		
6	17. 3. 1933	8. 4. 1933	22	Linear reservoir			Linear reservoir		
7	21. 4. 1934	10. 5. 1934	19	Linear reservoir			Linear reservoir		
8	3. 9. 1934	18. 9. 1934	15	Linear reservoir			Linear reservoir		
9	19. 6. 1935	6. 7. 1935	17	Linear reservoir			Linear reservoir		
10	10. 7. 1936	30. 7. 1936	20	Linear reservoir			Linear reservoir		
11	5. 8. 1936	20. 8. 1936	15	Linear reservoir			Linear reservoir		
12	10. 9. 1936	30. 9. 1936	20	Linear reservoir			Linear reservoir		
13	15. 4. 1937	9. 5. 1937	22	Linear reservoir			Linear reservoir		

Save Cancel

Fig. 21. The options of single recession curve analysis program results export (above - calculated results which were shown in a chart; below - the results of comprehensive analysis of all recession curves)

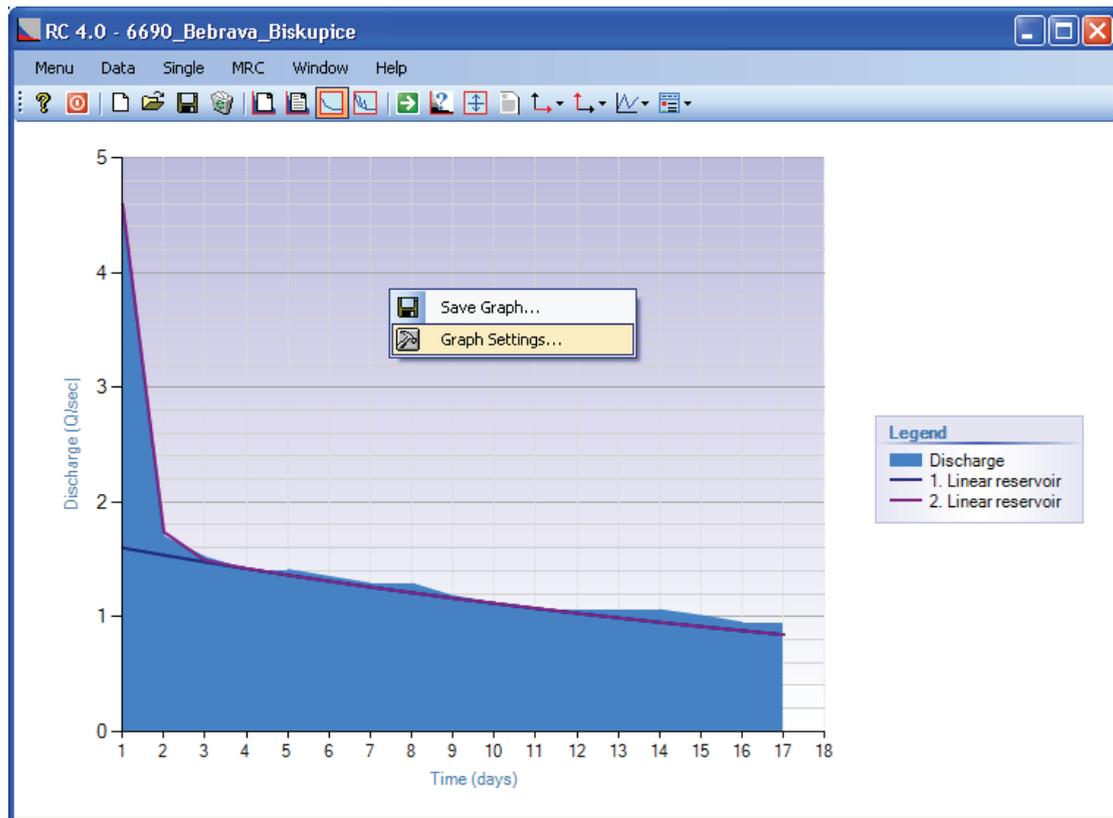


Fig. 22. Other functions displayed after the right-click on the chart

Next chapters are devoted to the description of processing and analysis of master recession curves.

8 MANUAL CREATION OF THE MASTER RECESSION CURVE

As mentioned previously, in addition to the individual recession curves, the RC 4.0 tool enables the user to create and analyse also the master (assembled) recession curve. The master recession curves can be assembled either manually or by automated tool. In this chapter, a tool for the manual assembly of master recession curve will be presented (Fig. 23).

This tool is displayed by a menu command **MRC - MRC Creating Manually**. When executed, the window appears as shown on Figure 23. Into this window the selected recession curves are loaded, and shown on a chart. The individual curves are not ordered by time, and the task for the user is to move them individually on the timeline (horizontal axis), to form one continuous master recession curve. The table shown on the left part of the window (Fig. 23), all recession curves is listed. The **Shift** parameter contains a value of selected recession curve shift on the timeline. Last editable parameter – **Use** – defines whether the given recession curve is used or not. If this value is set to False, then the given recession curve remains hidden on the chart and will not be used for further analysis. Before we can start to move the recession curve on the timeline, it should be selected. The recession curve is selected either by clicking on its row in a table (left part of the window), or by the buttons “<” and “>” below the graph. Selected recession curve is highlighted in a graph by red colour. The recession curve already selected can be moved on a timeline by using the scrollbar below the graph. The range of possible shift is defined by the values in the textboxes before and after the scrollbar.

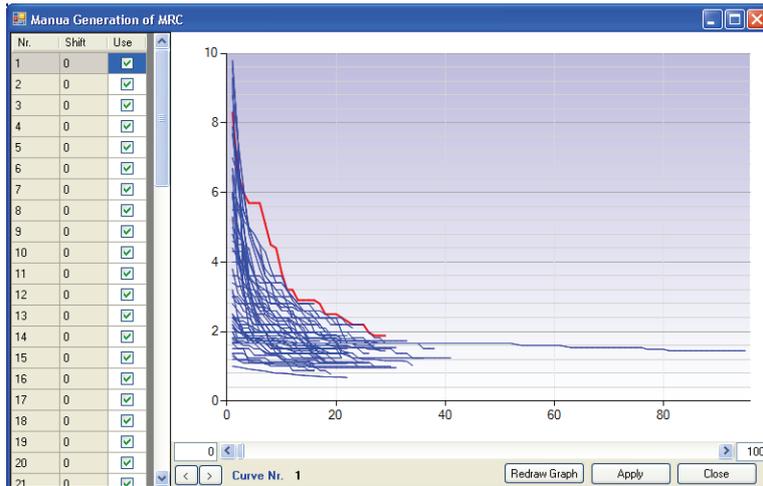


Fig. 23. Tool for the manual assemblage of master recession curve

When satisfied with the result, the shift can be exported to the main window by the button **Apply**. Figure 24 shows a result example of the master recession curve assembled from the input data shown on the Figure 23. After clicking the right mouse button on the graph, also other functions to change the chart view are shown. For the axes, the views can be defined as linear or logarithmic (Fig. 24b).

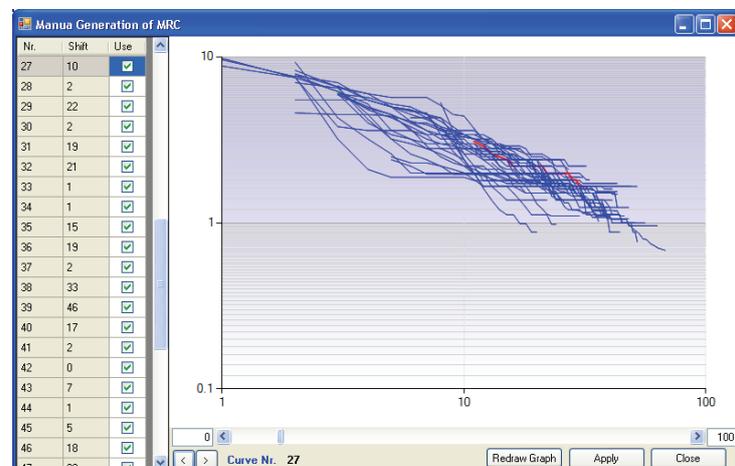
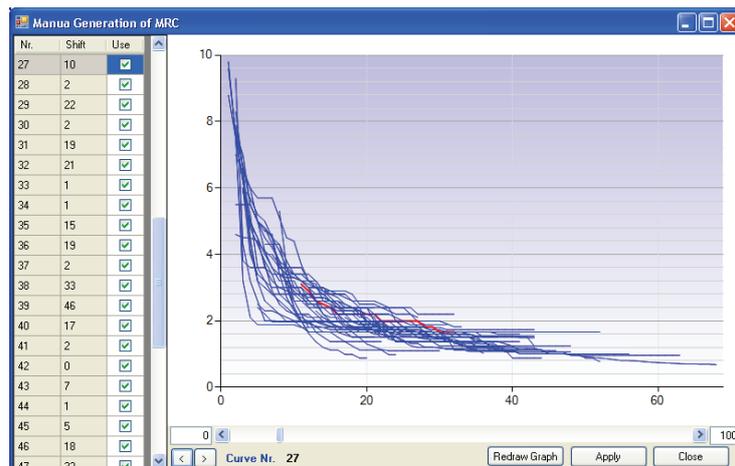


Fig. 24. Master recession curve created by manual assembling (a – result of Fig. 23 data processing; b – logarithmic view of the master recession curve)

9 AUTOMATICALLY CREATED MASTER RECESSION CURVE

Another way of creating the master recession curve in the RC 4.0 tool is to use the in-built, automated tool that applies components and methods of artificial intelligence: a combination of method of strongly hybridised genetic algorithm and method of artificial immune network. A great advantage of this algorithm is that it enables a master recession curve assemblage in the cases, where other methods are not sufficient or effective. This is particularly the case when:

- a small number of recession curves from the time-series is available;
- a short time-series of discharge measurements are available;
- recession is very complex, described for example by a combination of several laminar and turbulent sub-regimes;
- selected recession curves are affected by the hydrological situation (e.g. long-term rainfall events);
- only fragments of the recession curves are available.

Method itself is quite complex and its theory is described in a separate paper (Gregor and Malík 2012). The effort to create this method was focused especially to reach ability of such master recession curve creation, which will describe the course of recession from the state of maximum repletion of the hydrological system (catchment) / hydrogeological structure to the lowest documented depletion. Moreover, these recession regime should characterize the runoff unaffected by the dynamic parameters (e.g. meteorological and climatic parameters in the catchment), but dependent only on the hydraulic properties of the hydrological system / hydrogeological structure. Also, this method should be applicable in cases described in the aforementioned list, where other methods are not appropriate. Moreover, the result should not be affected by the author's previous experience and should be automated, compared to the previous method of manual assembling.

The whole process of automated creation of master recession curve will be described gradually for each step. The first step is to display a separate window for automatic processing. This window displays after clicking on the menu **MRC - MRC Creating the GA** (Fig. 25).

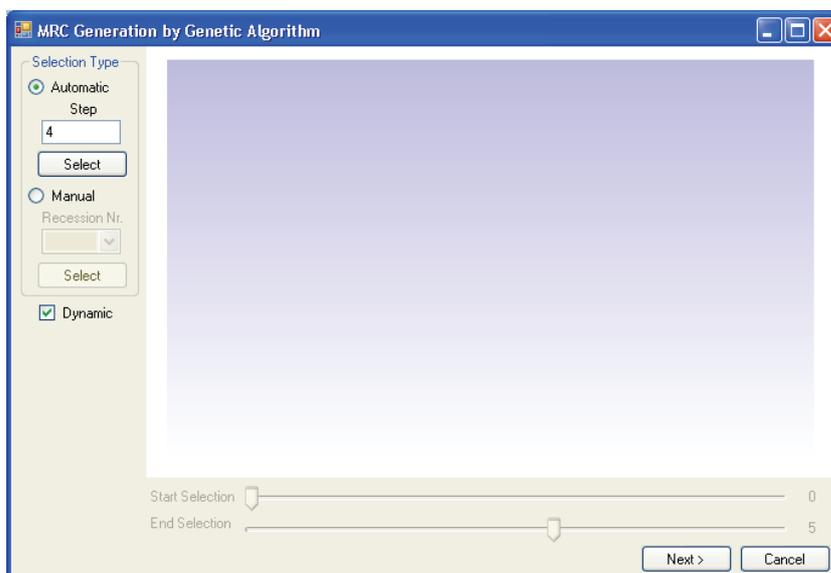


Fig. 25. Running an automated tool for master recession curve assemblage

After this window is displayed, the user's task is the segmentation of selected recession curves into short segments. The whole method is based on the fact that for the assemblage of master recession curve, the selected recession curves cannot be applied in their entire duration, as each of them was originated under a different and unique hydrological situation and therefore each recession curve is unique. E.g., the shape of recession curves generated by snow melt differs from those arising from summer rainfall events. Therefore, all curves are split into short segments, describing the change in recession e.g. in a period of only few days. For the purpose of this segmentation, the tools in the right pane are used. Individual curves can be segmented either manually or automatically. In the development and testing phase of this tool, an automatic segmentation was most frequently used. To run the automatic segmentation method, set the segmentation step in days (or weeks) and choose the **Select** button (Fig. 25). The program then automatically segments each recession curve into separate parts, which are N days or weeks long.

During the author's work experience, optimal input for an automatic selection of recession segments (duration length of the segments) was four consecutive measurements (4 days or weeks) had been observed.

The second option is a manual segmentation, which is not so frequently used, but can be helpful in some cases, e.g., in a need of manual removal of the artificially affected recession sections from the analysis. For this purpose, we choose the option of manual selection in the combo box **Recession Nr.** Here, the order number of the selected curve is chosen and the recession curve is depicted on the chart (Fig. 26).

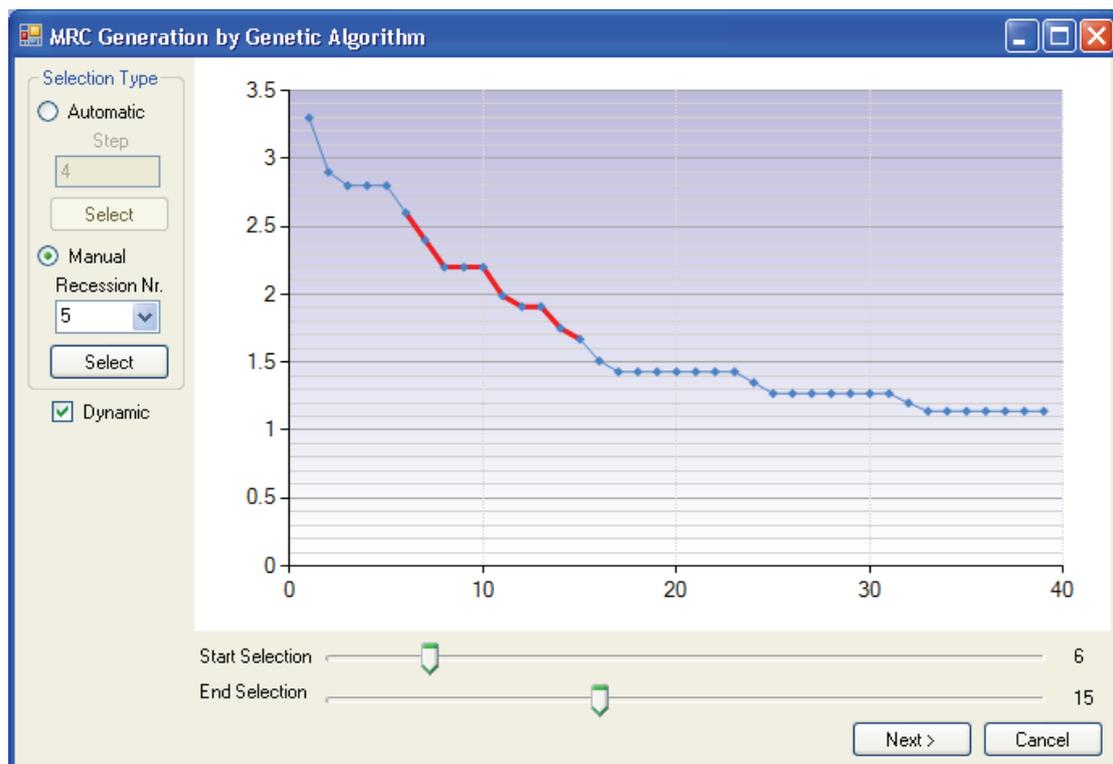


Fig. 26. Manual segmentation of recession curves

Bottom sliders enable marking the time interval of the recession curve, to preserve the selection press the **Select** button. Highlighted section is then exported into the next step. In this way we can continue until all the necessary sections of the recession curves are selected. After all individual segments had been selected, to

perform the next ongoing step of the process, the button **Next >** should be applied. Then, a second window (Fig. 27) is shown to continue the processing.

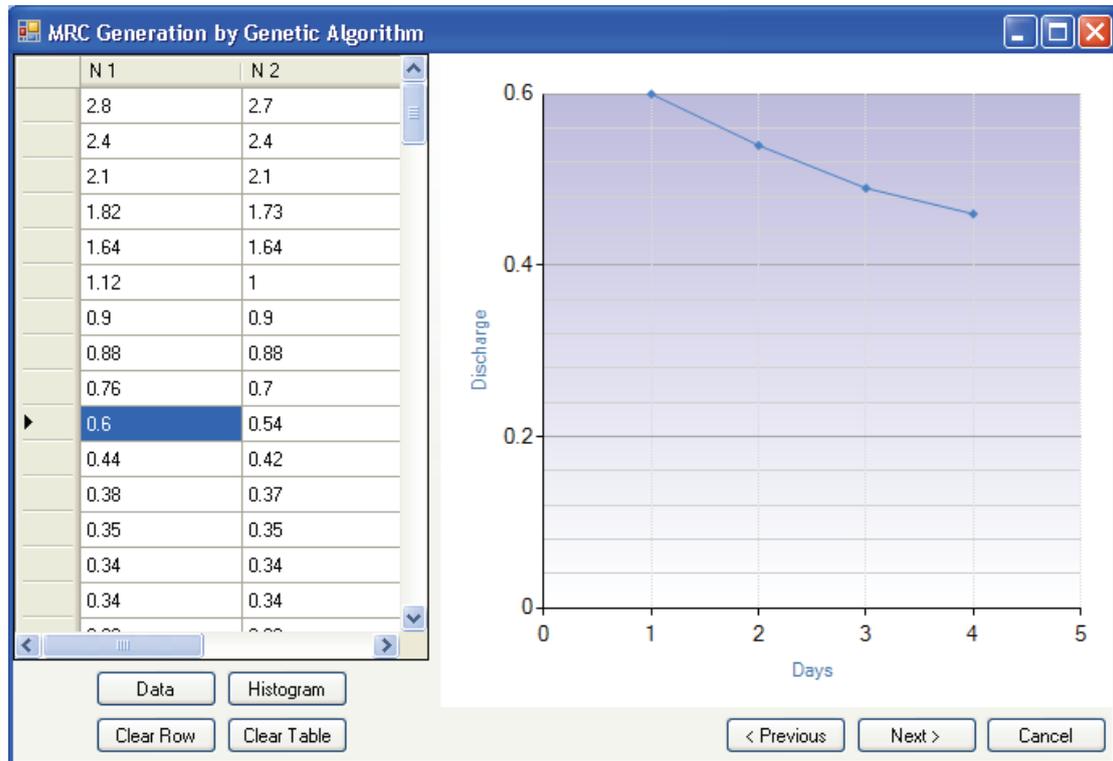


Fig. 27. Preparation and processing of the selected recession curves' segments

All the segments, which we had chosen in the previous step, are shown in the table of the second window. If the user clicks on the selected segment in the table, it is automatically plotted on the chart. Within this step, we can prepare and process segments in different ways.

One of the processing possibilities is direct and manual editing of data in the table, where we can manually change the values in segments' selection or we can completely delete them, e.g. in cases when the values in segment are not decreasing (constant) and so on. To delete the selected row of the table we use the **Clear Row** button. To delete the entire table we use the **Clear Table** button.

For the most accurate assembling of the master recession curve results, it is necessary to obtain sufficient number of segments for each discharge interval, from the highest to the lowest measured value. This requirement of regular distribution of values cannot be satisfied in many cases. However, we can reduce the non-uniformity of frequency of the values in the selected segments by other tools.

For visual analysis of the frequency distribution of discharges, the **Histogram** button can be used, to show the relative frequency of measured discharge values in different sections. Figure 28 shows the histogram before and after the data treatment. The comparison shows, that after adjusting of the data, the frequency distribution of the discharge values is more uniform. This means that for the following run of the algorithm, fewer cycles will be required and the evolutionary algorithm will run faster, as the smaller amount of data should be processed.

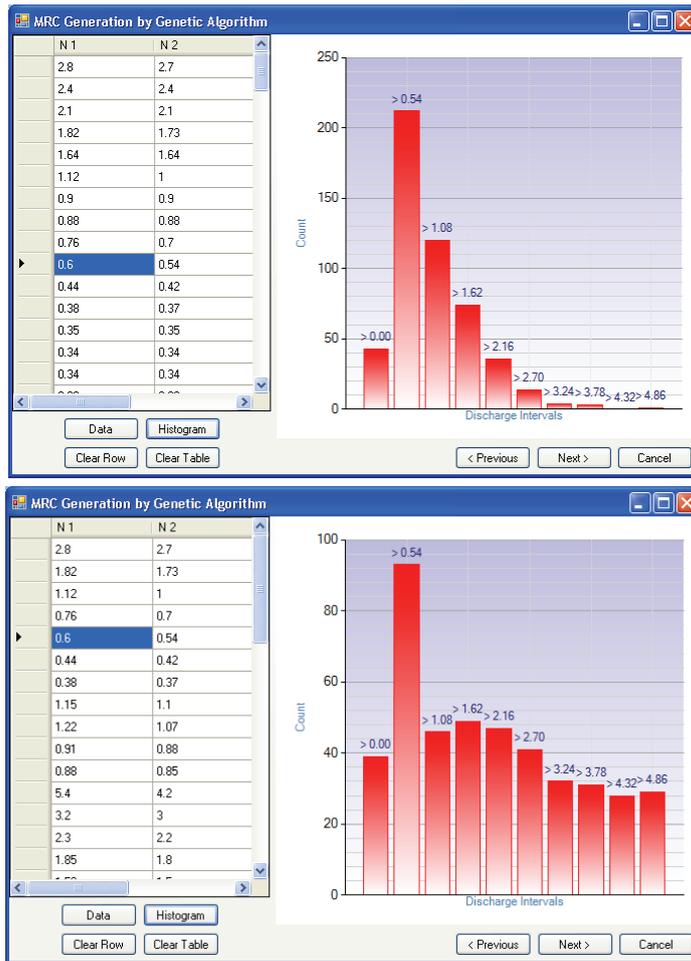


Fig. 28. Discharge values frequency in selected recession segments before (top) and after (bottom) their adjustments

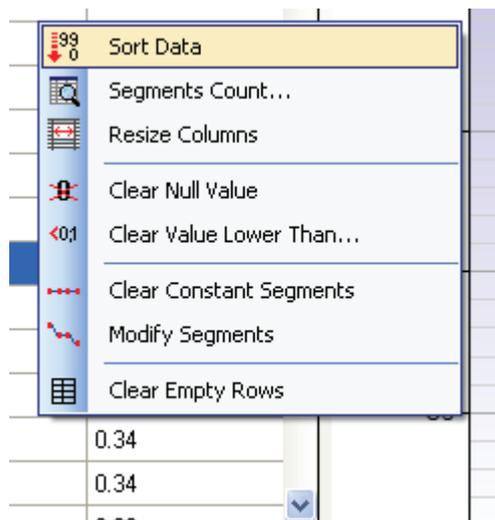


Fig. 29. Functions for discharge values adjustment in selected recession segments

For the data processing within the program, a number of functions were prepared. Right clicking of the mouse on the table or pressing the **Data** button in the window enables access to all these functions.

List of the data processing functions (after pressing the **Data** button) is demonstrated on *Figure 29*.

As the first on the top, **Sort Data** function sorts the selected segments in the table by the discharge measured on the first day of the respective segment, from the highest to the lowest values. Function **Segments Count** counts the number of segments. **Resize Columns** feature automatically changes the column width. **Clear Null Value** function deletes all records with the zero discharge. The function **Clear Value Lower Than** deletes all records of discharge, which is lower than the value specified by the user.

Clear Constant Segments feature deletes all segments in the table, where all the measured discharges are constant. Conversely, the function **Modify Segments** is used to delete constant values in the segments, where not only constant values are present. In the case that after deleting of these values the length of the selected segment will be one day (/one week), the program deletes the entire segment, as the minimum length of the segments is 2 days (or 2 weeks). If after the processing the table contains several blank rows, it is necessary to delete them. For this purpose, the function **Clear Empty Rows** should be applied.

All the described features can be used in the case of the sufficient number of selected segments (more than approximately 150 segments). In the cases of limited

number of segments, also the segments with constant discharge should be processed in the subsequent analysis.

After the analysis and adjustment of selected segments, we move to the next step simply by pressing the button **Next >**. After pressing it, a window displayed as in **Figure 30** appears.

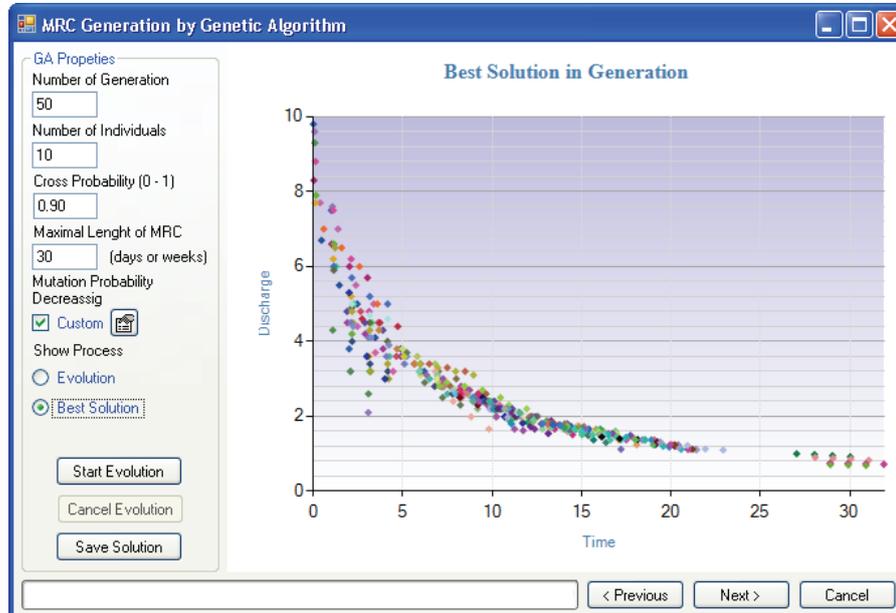


Fig. 30. Setting and processing of the genetic algorithm, applied for the master recession curve assembling

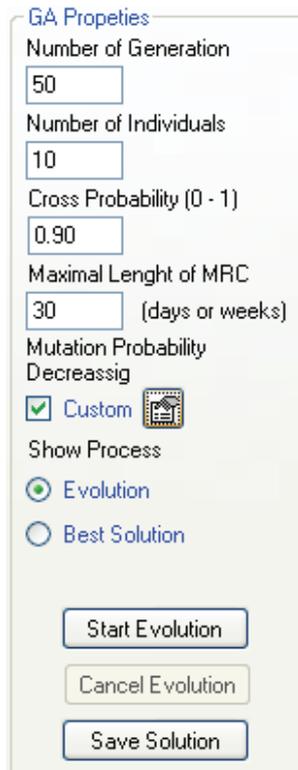


Fig. 31. The settings of genetic algorithm

Within this phase of the process, as shown in the window on **Fig. 30**, the master recession curve is already created by a final procedure. In the left part of the window, the user can set various parameters, and in the right – graphical part – the user can directly see the partial results of the algorithm process run.

As already mentioned, in this procedure a method of genetic algorithms was applied, and the algorithm itself is strongly hybridised. The algorithm settings can be found in detail on **Figure 31**. If you are not familiar with the theory of genetic algorithms methods, before using this tool a further study, or at least acquisition of its basics, is recommended. For an experienced user, familiar with genetic algorithms, the setting of parameters and their possible influence on the course of the algorithm will be much clearer and easier. Theoretical background of genetic algorithm applied is explained in a separate paper, and the following description is therefore concentrated only on algorithm setting and running.

The first step is to set the number of evolutionary cycles in the parameter **Number of Generation** (**Fig. 31**). Majority of the known genetic algorithms requires for finding the result with sufficient accuracy more than 200 evolutionary cycles. Our algorithm, however, due to its hybridisation, requires less

cycles. Predefined number of cycles in the program is 50. This number, of course, can be changed according to the needs of the user.

Similarly to the number of cycles, also the **Number of Individuals** parameter in this algorithm is lower less than in usual cases of genetic algorithm applications. The program is set to predefined number of individuals in calculation of 15. If we have obtained enough recession segments and the measurements are unaffected and accurate enough, it is already possible to reduce this number and vice versa. However, it is important to understand that by the increase of the number of individuals, the running time of the algorithm significantly increases as well. Parameter **Cross Probability** defines the crossing probability of individual solutions (individuals). Predefined probability is 0.9 and this value is considered to be optimal for the run of the calculation. However, the range of probability can be chosen from 0 to 1.

Another parameter is the **Maximal Estimated Length of Master Recession Curve**. This parameter cannot be determined exactly before the run of the algorithm, and therefore can be estimated only approximately from the length of the individual recession curves that had been selected. This parameter is therefore defined only as an approximate. If we find after the calculation, that this parameter was set as too high, in the next-time run we should reduce it and run the algorithm again. On Figure 32, the influence of the incorrect maximal length of the estimated master recession curve setting is displayed.

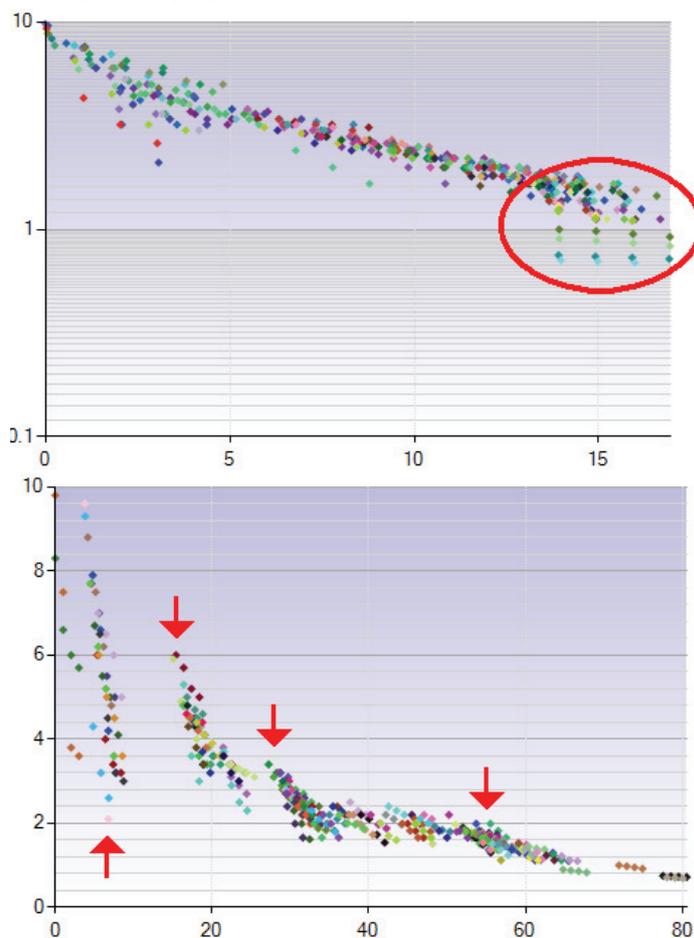


Fig. 32. Incorrectly specified values of master recession curve maximum length (top – too small; bottom – too high value)

the maximum master recession curve length is (in this case) about 25 days (Fig. 30).

Due to its definition, it seems to be better, if this parameter is set slightly higher than necessary, as the algorithm is able to automatically truncate the generated master recession curve, as shown on Figure 30. However, if this parameter is set as too small, on the end of the assembled recession curve the segments with lower discharges will cumulate (Fig. 32, above). In the case the maximum length of master recession curve is set as too long, the calculation process will aggregate the segments into separate groups and the master recession curve will be not created. On Figure 32, the results of processing with different length extremes are shown, in the upper case the maximum length was set to 15 days, in the lower (too high value) for 80 days. The optimum value for the

The final parameter, used for setting of the genetic algorithm, is the **Mutation Probability**. According to the specifics of a master recession curve assembling, mutation in this algorithm has a different character, the principle of mutation is described in detail in a separate paper. For the mutation probability management in the algorithm applied, it is important to note that the mutation happens not with the low probability, but every time on the cross of the solutions. In addition, for efficient run of the algorithm, a procedure reducing the range of possible mutations in time was developed. In our program, this range is preliminary set to a certain extent, but it is often necessary to change this range. If the user wants to let the default range of mutation, the checkbox **Custom** must be set to **False**. If the user wishes to change the mutation probability parameter, it is necessary to set the **True** value in the checkbox and then to click on the button on the right side. The parameters important for setting the mutation probability will appear then in the upper right part of the window (Fig. 33).

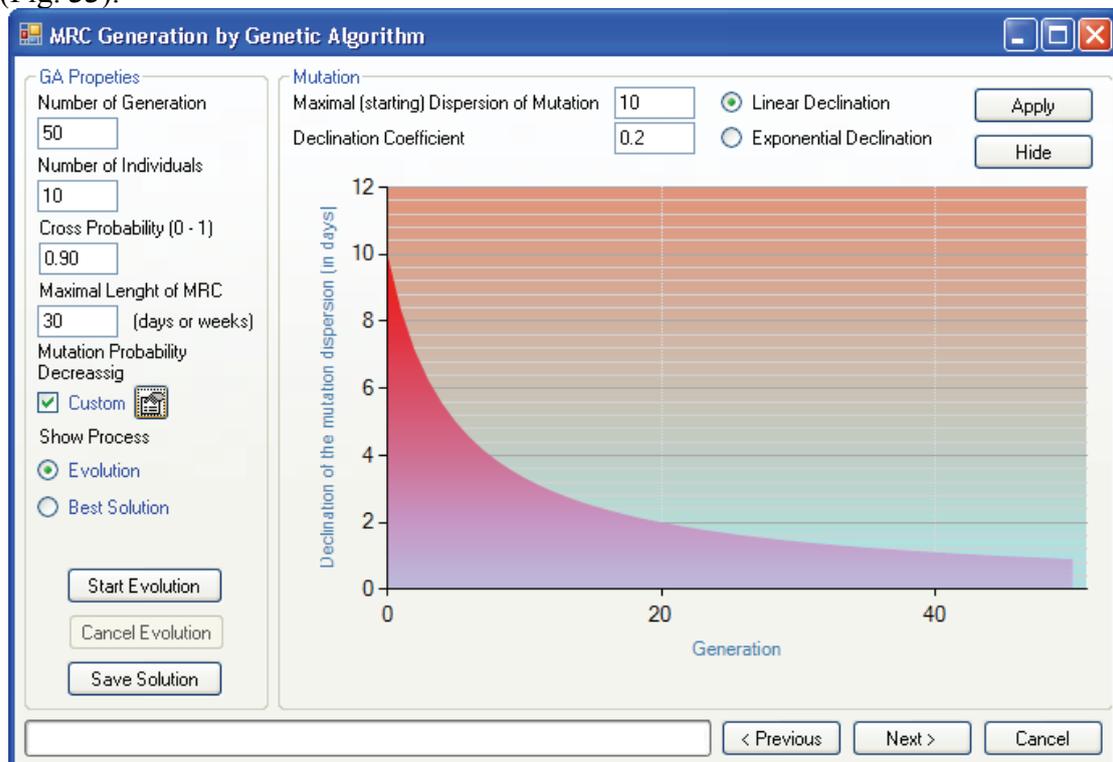


Fig. 33. Setting of mutation parameters for the run of algorithm cycles in time

In this step, mutation probability range with the passage of time is defined. As the first, a parameter **Maximal Dispersion of Mutation** is to be set. This parameter defines the number of days range, within which is the mutation randomly calculated. This mutation is added or subtracted from the shift of the segment on the timeline, and the segment obtains a new position in time. **Declination Coefficient** parameter defines the decrease of extent of possible mutations in time. This decrease can be set as linear or exponential. This means, that the mutation decreases in time of the evolutionary cycles. When satisfied with the mutation parameters set up, just click on the **Apply** button to set them and return back.

As shown on Figure 33 the extent of possible random mutation is 10 days for the first generation, 2 days for the twentieth generation, and just only 1 day for the last, fiftieth generation.

According to the described procedure, we set all the parameters required for the run of this algorithm, and now we can start this process. The run of the algorithm is started by pressing of the **Start Evolution** button. The program will then perform the calculations, and the whole process may take even several minutes. The running time of the algorithm depends on the number of selected segments from the recession curves, number of evolutionary cycles, number of parallel-solved solutions (individuals) and on the master recession curve maximum length parameter. We can observe the whole process of algorithm performance on the graph, in the two types of display (Fig. 34). The form of this view can be chosen in the **Show Process** section (Fig. 31) as “**evolution**” or “**best solution**”.

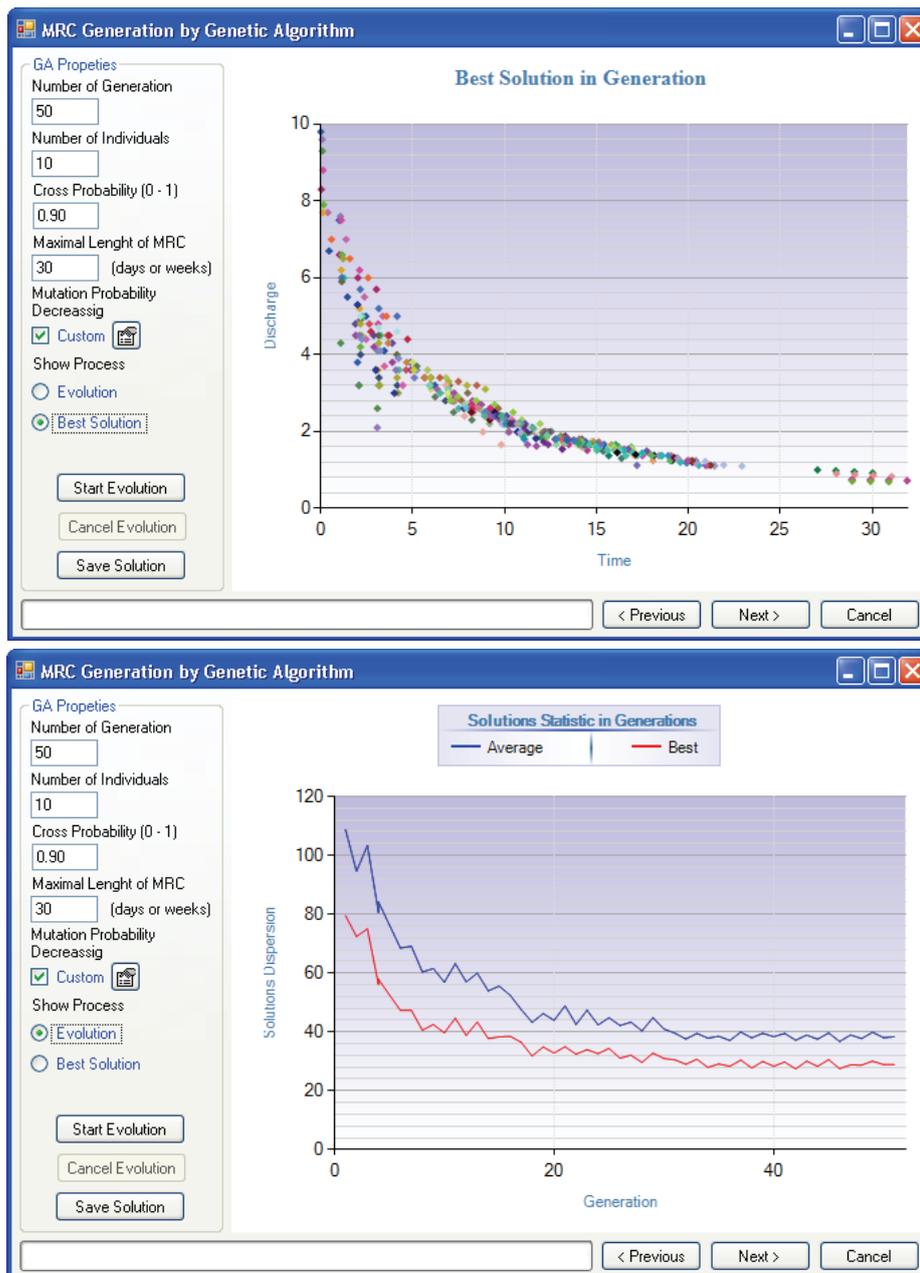


Fig. 34. The view on the evolutionary algorithm performance (top – visualization of the best solution in generation; bottom – development of solution dispersion in the evolutionary cycles)

The first way of the algorithm calculating process observation is tracking of the best solution in generation (Fig. 34 above). In this case, the program shows the best solutions on the runtime. The result of the algorithm is then the best solution in the last generation.

The second way of process monitoring is by the visualization of solution dispersion values in time (Fig. 34 below). The dispersion chart shows dispersion values of the best solution in generation, and average dispersion value for whole generation. In this tool the dispersion is described as an area that covers one solution in one generation (Fig. 35). The course of the process development (in the “best solution” window) would be gradually seen as in Figure 36.

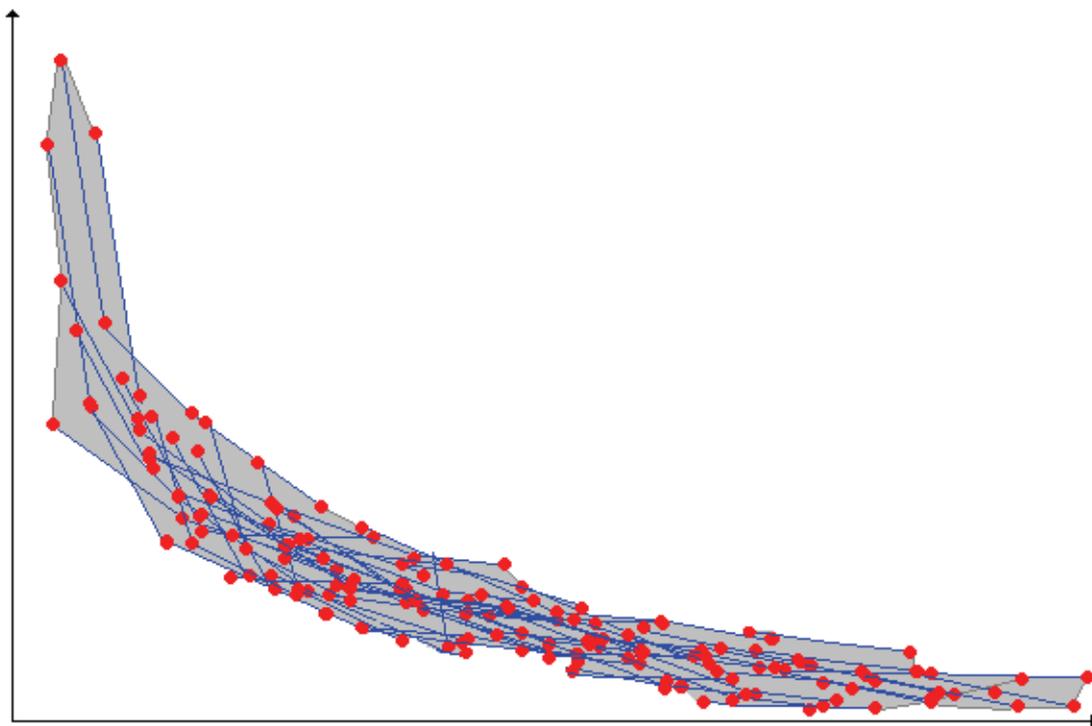


Fig. 35. Definition of dispersion value in individual solution from the respective generation (highlighted gray area)

After the completion of algorithm performance, the best solution from the last generation remains displayed on the chart. By the right-click on the chart, the user can change from linear view of Y-axis to a logarithmic view and vice versa, and it is also possible to export the graph from the program into the image file.

Algorithm performance can be terminated during its run by **Cancel Evolution** button, and the program then offers the opportunity to save the intermediate results. If we are already satisfied with the solution of master recession curve, by the use of **Save Solution** button we can save the results. The advantage of this program is, that the partial result can be saved and stored, and the calculation can continue with altered input parameters (mutation, the maximum length of master recession curve, etc.). During the testing and algorithm performance by the author, it was found that for the sufficient accuracy of master recession curve automated assembly it is appropriate to run the algorithm at least 3 times, with various parameter values (particularly the mutations), and then choose the best solution. With longer use of the program the user gradually learns how to adjust various parameters more and more effectively, to decrease the number of algorithm runs repetitions to minimum.

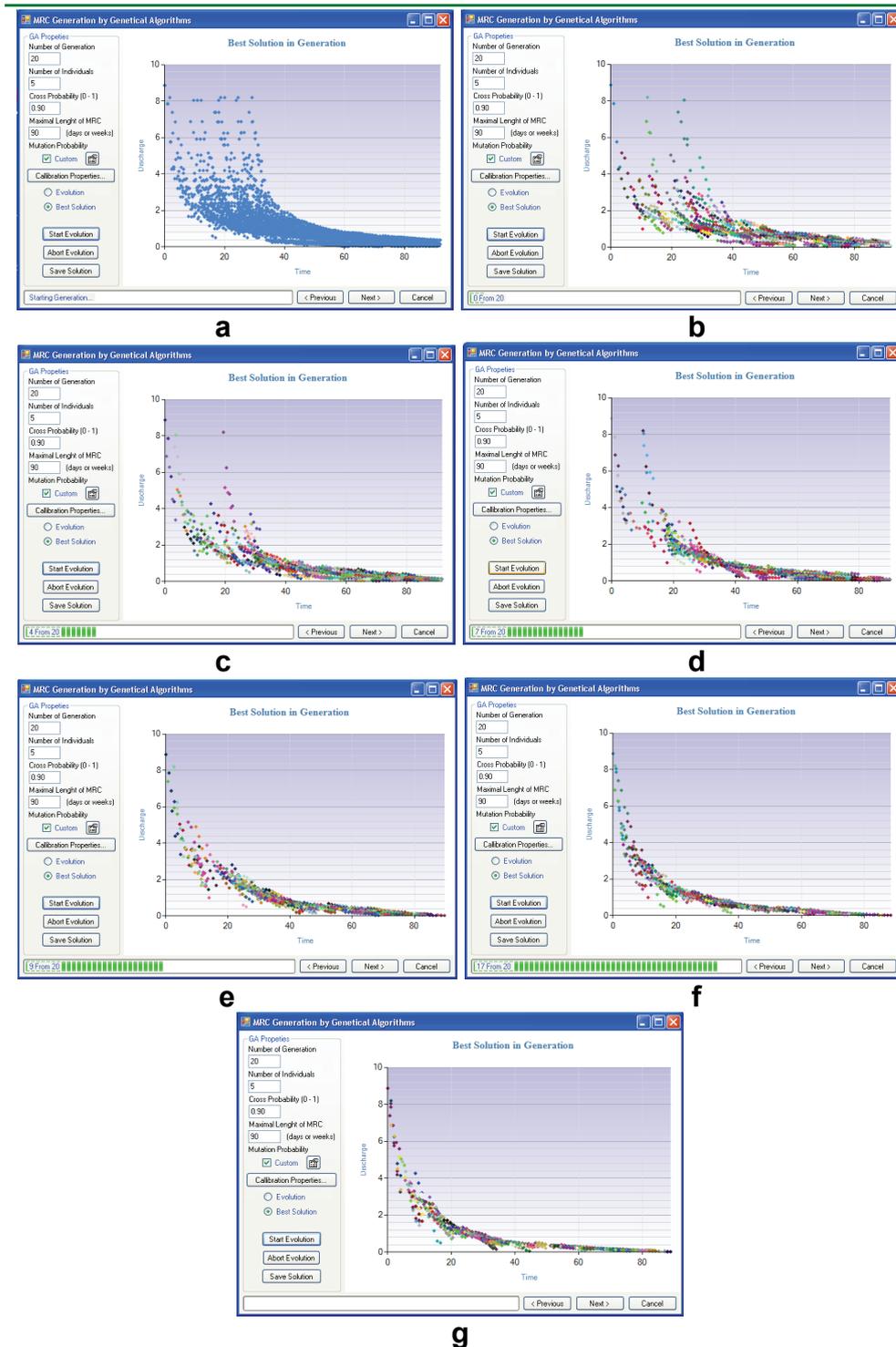


Fig. 36. Visualisation of the best solutions in generation during different generations of algorithm run (a – all solutions in the first, introductory generation; b – second generation; c – third generation; d – 6th generation; e – 11th generation; f – 18th generation; g – final generation)

After completing of several runs of the algorithm, and after saving of several versions of the created master recession curves, the user can proceed the last step by pressing the button **Next >**. A window that appears then is shown on Figure 37.

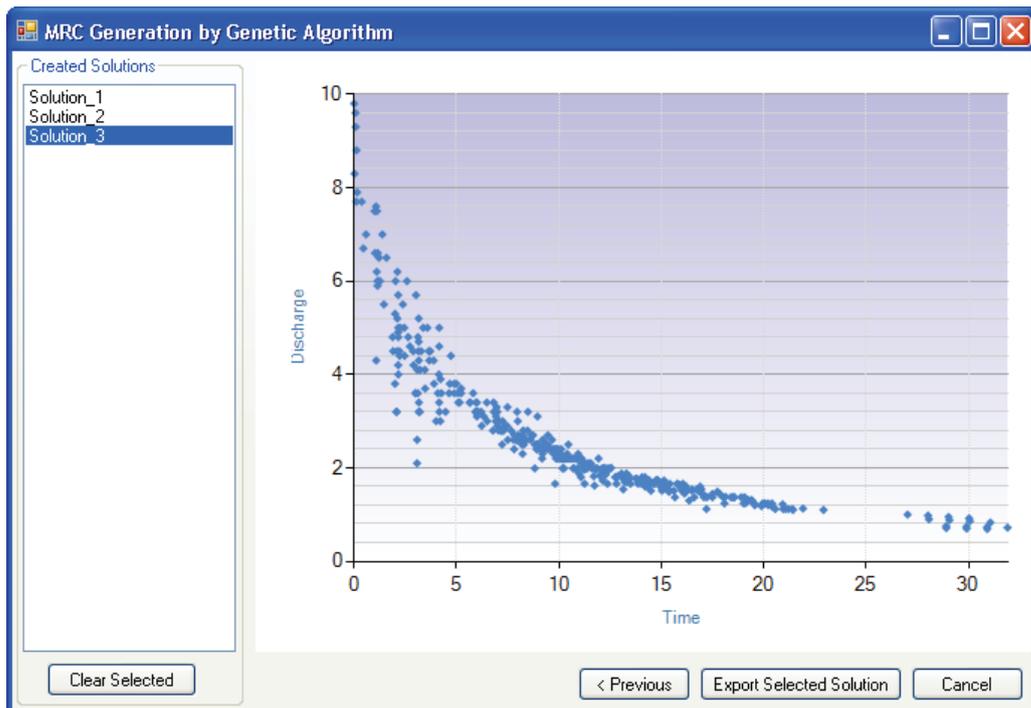


Fig. 37. Selection of the best assembled master recession curve from all acquired evolutionary solutions

Within this window (Fig. 37), the user selects the most appropriate solution of master recession curve. If the algorithm performances were acted correctly, individual solutions can be very similar and the user then chooses the most compact (without empty intervals) solution. After clicking on the button **Export Selected Solution**, the selected solution is exported into the main window (Fig. 38).

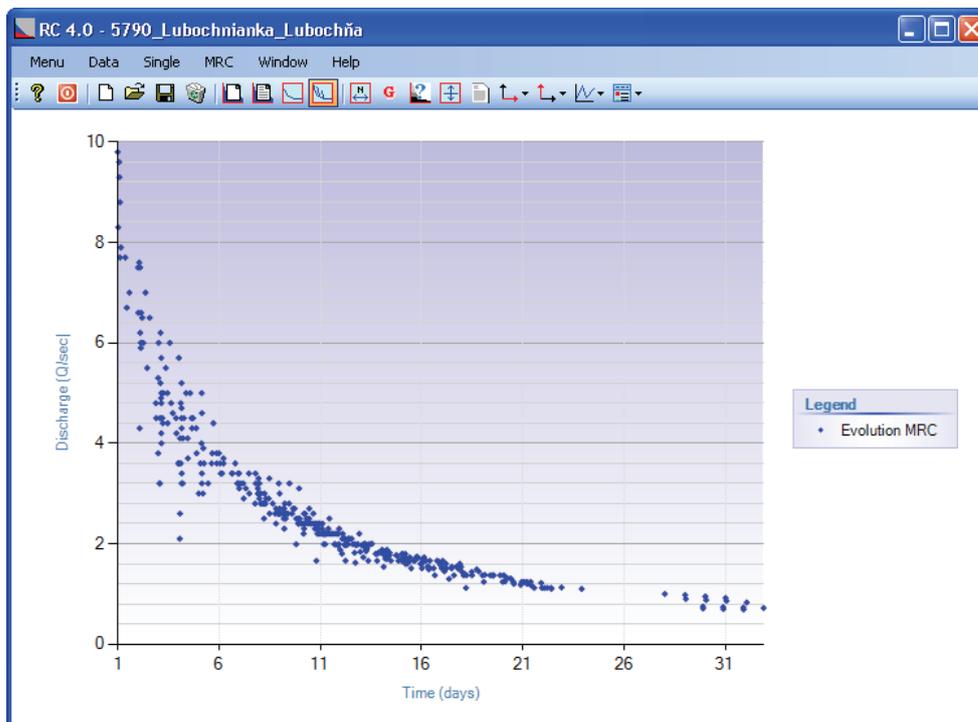


Fig. 38. Example of the exported best solution of master recession curve

10 ANALYSIS OF THE MASTER RECESSION CURVE

In the previous text, two methods of the master recession curve assembling were presented. Both of them can be used for the analysis described in the following text, and the user can switch between them. For switching between the manually and automatically created master recession curve display, the user can use the tools that appear after the right clicking on the chart area in the main window (Fig. 39).

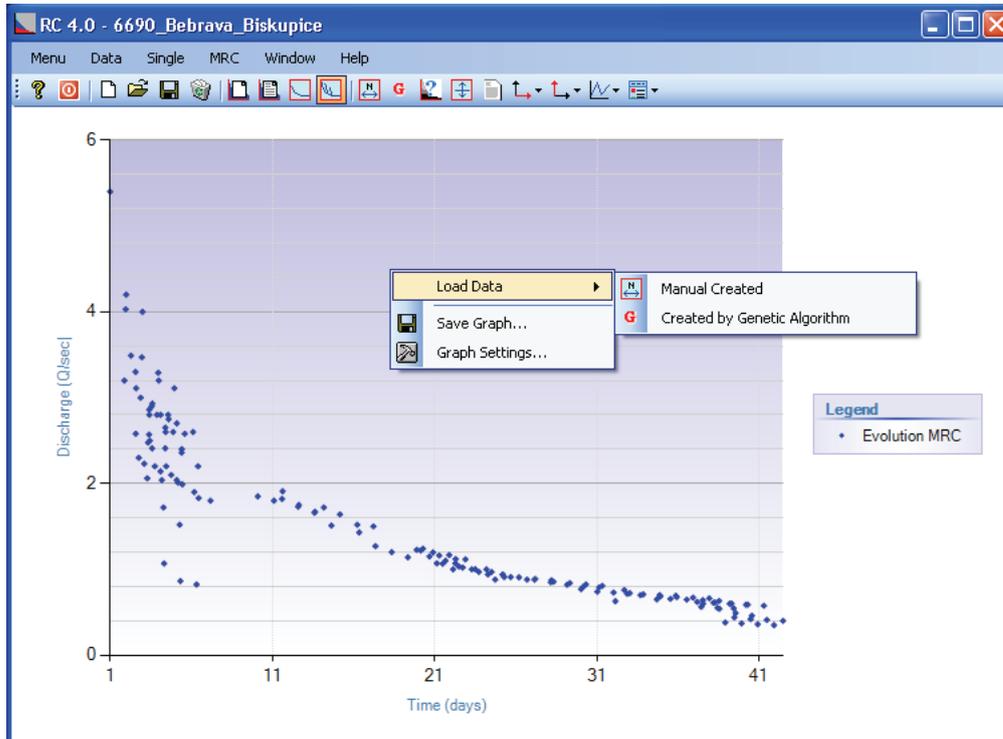


Fig. 39. Switching between views of manually / automatically created master recession curves

Sequence of the next steps is similar to the analysis of individual recession curves. At first, the user should define the type and number of recession function in sub-regimes in an auxiliary form, showed by a command **MRC – Model Selection** (Fig. 40).

The screenshot shows the "Model Selection - Cumulative Recession Curve" dialog box. The title bar reads "Model Selection - Cumulative Recession Curve". The main text says "Select the number and type of sub-regimes of recession". There are four rows, each representing a sub-regime. The first two rows are checked, and the last two are unchecked. Each row has a dropdown menu for selecting the type of recession function. The first two dropdowns are set to "Linear reservoir". An "OK" button is located at the bottom center of the dialog.

Sub-regime	Type
<input checked="" type="checkbox"/> 1. sub-regime	Linear reservoir
<input checked="" type="checkbox"/> 2. sub-regime	Linear reservoir
<input type="checkbox"/> 3. sub-regime	Linear reservoir
<input type="checkbox"/> 4. sub-regime	Linear reservoir

Fig. 40. Setting of number and type of recession function, used for recession parameters and coefficients analysis

After the number and type of recession function are defined, the user should use another auxiliary form for adjusting and calibrating the recession parameters and coefficients by command **MRC – Calibration Form** (Fig. 41). This form is also similar to the form used in the analysis of individual recession curves, but – in difference – it doesn't contain buttons for selection of recession curve. Other functionality is exactly the same as in the case of individual recession curves analysis.

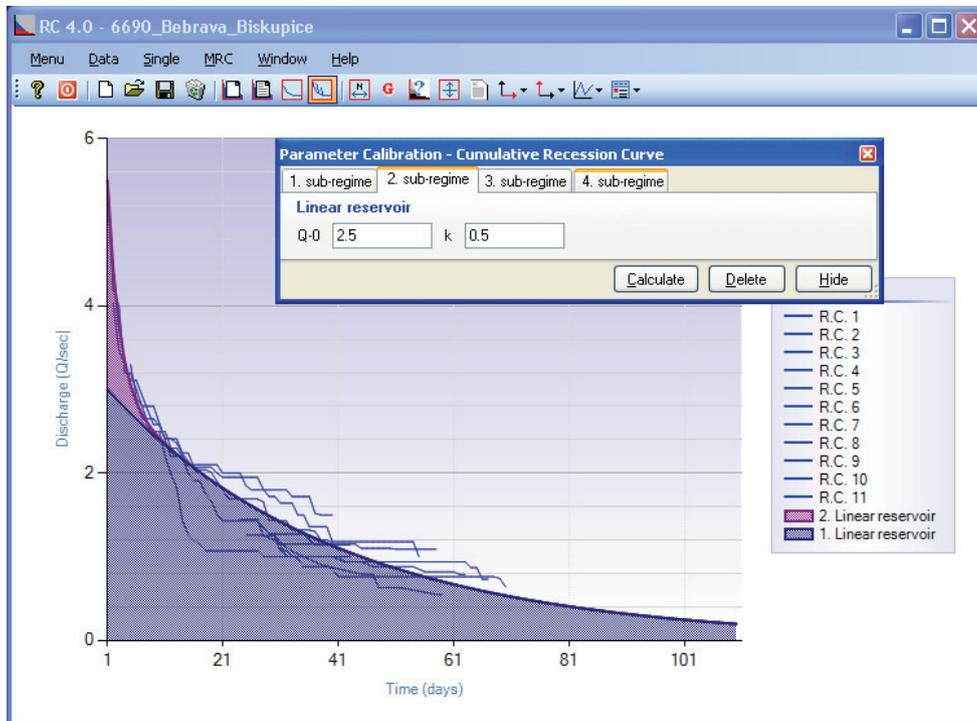


Fig. 41. Calibration of recession parameters and coefficients of master recession curve

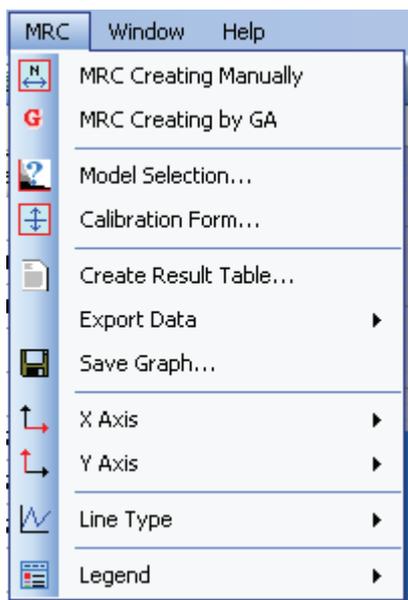


Fig. 42. The functions for processing and analysing of master recession curves

Similarly, also other functions described in the analysis and processing of individual recession curves are the same, but they are grouped in the next menu item - **MRC** (Fig. 42).

The possibilities of export of the computed results are different in comparison to the analysis of individual curves the user can also export the resulting values of the recession coefficients and parameters in the same way (Fig. 43). Table of results consists of one line, in which individual sub-regimes and their recession coefficients are defined. This table will appear after clicking on the command **MRC - Create Result Table** (Fig. 42). Using the **Save** button, these results can be exported from the program.

Another option of results export is to export calculated discharge values in individual sub-regimes on the timeline, for time intervals previously selected (Fig. 44). Such a table will be created by using a command **MRC - Export**

Data - Calculated Recessions. The first column defines the time period (days or

1.subregime			2.subregime		
	Q_0	k		Q_0	k
Linear reservoir	3	0.025	Linear reservoir	2.5	0.5

Fig. 43. Table of results from analysis of individual master recession curve

Time (days)	Calculated Subregime 1	Calculated Subregime 2	Calculated SUM
1	3.10E+00	6.80E+00	9.90E+00
2	2.96E+00	4.79E+00	7.76E+00
3	2.83E+00	3.38E+00	6.21E+00
4	2.71E+00	2.38E+00	5.09E+00
5	2.59E+00	1.68E+00	4.27E+00
6	2.48E+00	1.18E+00	3.66E+00
7	2.37E+00	8.33E-01	3.20E+00
8	2.26E+00	5.87E-01	2.85E+00
9	2.16E+00	4.14E-01	2.58E+00
10	2.07E+00	2.91E-01	2.36E+00
11	1.98E+00	2.05E-01	2.18E+00
12	1.89E+00	1.45E-01	2.03E+00
13	1.81E+00	1.02E-01	1.91E+00
14	1.73E+00	7.19E-02	1.80E+00
15	1.65E+00	5.06E-02	1.70E+00
16	1.58E+00	3.57E-02	1.61E+00
17	1.51E+00	2.51E-02	1.53E+00
18	1.44E+00	1.77E-02	1.46E+00
19	1.38E+00	1.25E-02	1.39E+00

Fig. 44. Exported values of discharge in individual sub-regimes

respective day of recession, following columns contain the measured discharges at selected recession curves, which are already shifted in time.

If an evolutionarily formed master recession curve is displayed in the chart, the table will have a structure as shown in the bottom part of the Figure 45. In this case, the table will have only two columns. The first column will contain the time value (days / weeks), and the second column will contain the respective discharge value of recession.

In both cases, the values in the tables may be exported by the use of the **Save** button.

weeks). Other columns contain values of the discharge in each sub-regime. Number of sub-regimes depends on the previously defined value (Fig. 40). The last column contains the final sum of sub-regimes' discharges, i.e. the values of the total calculated discharge in the defined day.

The last option is the export of the generated master recession curve. The

master recession curve can be exported by using the command **MRC - Export Data - Master Recession Curve**. This command can generate two types of results (Fig. 45).

The structure of the exported table for individual master recession curve is dependent on its type.

If a manually created master recession curve is displayed on the chart, the resulting table will look like the one displayed in the upper part of the Figure 45. The first column represents time and contains the value of

Other commands are the same as for the analysis of individual recession curves, such as commands used for visual adjustments of graphs (Fig. 42).

The figure shows two screenshots of the 'Table Results' window. The left window displays a table with columns for Time (days) and RC 1 through RC 9. The right window displays a table with columns for Time (days) and Discharge.

Time (days)	RC 1	RC 2	RC 3	RC 4	RC 5	RC 6	RC 7	RC 8	RC 9	RC
1										
2			4.60E+00				7.90E+00			
3			4.50E+00				6.60E+00			
4			4.50E+00				4.20E+00			
5			4.40E+00		2.40E+00	2.50E+00	3.20E+00			
6			3.70E+00		2.20E+00	2.30E+00	2.60E+00			
7			2.90E+00		1.97E+00	2.30E+00	2.40E+00			
8			2.50E+00		1.97E+00	2.20E+00	2.20E+00			
9			2.30E+00		1.97E+00	2.10E+00	1.97E+00			
10			2.20E+00	2.20E+00	1.97E+00	2.00E+00	1.97E+00			
11		2.20E+00	2.10E+00	1.97E+00	1.97E+00	2.00E+00	1.97E+00			
12		1.80E+00	1.97E+00	1.97E+00	1.97E+00	2.00E+00	1.92E+00			
13		1.80E+00	1.97E+00	1.97E+00	1.97E+00	2.00E+00	1.84E+00			
14		1.80E+00	1.93E+00	1.97E+00	1.88E+00	2.00E+00	1.80E+00	1.66E+00		
15		1.80E+00	1.84E+00	1.97E+00	1.80E+00	1.93E+00	1.80E+00	1.66E+00		2.50
16		1.80E+00	1.80E+00	1.97E+00	1.80E+00	1.84E+00	1.80E+00	1.66E+00		2.20

Time (days)	Discharge
0.00E+00	9.80E+00
2.31E-02	8.30E+00
6.77E-02	9.60E+00
8.12E-02	9.30E+00
1.11E-01	7.70E+00
1.15E-01	8.80E+00
1.54E-01	7.90E+00
3.77E-01	7.70E+00
4.53E-01	6.70E+00
5.78E-01	7.00E+00
1.00E+00	7.50E+00
1.02E+00	6.60E+00
1.07E+00	7.60E+00
1.08E+00	4.30E+00
1.11E+00	6.20E+00
1.11E+00	7.50E+00
1.14E+00	5.90E+00

Fig. 45. The export options of created master recession curves: top – values from manually created master recession curve; bottom – values from evolutionary created master recession curve

11 CONCLUSION

This manual is aimed to describe the functionality and the way of use of the RC 4.0 tool focused on hydrological analysis.

The tool serves for complex and easy processing of recession curves, starting from its separation from discharge time-series, to final analysis of recession parameters and coefficients. In this tool, individual recession curves of master recession curve can be processed. For assembling of master recession curve, two approaches can be applied – a manual creation (assemblage) and the use of specifically prepared unique algorithm that combines options of strongly hybridised genetic algorithm method and method of artificial immune system. A great advantage of this tool is, that all partial results can be immediately stored and saved into separate XML file. These partial results can be later imported into the tool, and also after an interruption of the process, the user can return and continue with recession curves processing.

Application has several features that are described in the text in detail. In the case of problems with the tool, the user's forum on the HydroOffice.org web can be contacted and used. Videotutorials can be used in the further study of the tool 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](mailto:).

If you managed to successfully use this tool, it would be great to cite it in your output. If you do not know how or what to quote, on project web page you can find the publications focused to HydroOffice software and its tools. 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 HydroOffice webpage.

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