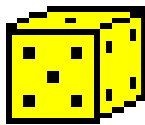


Modelling of contamination propagation in
groundwater systems using the random walk method

GGU-CONTAM-RW

VERSION 4



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Copyright:	GGU Zentrale Verwaltung mbH, Braunschweig
Technical implementation and sales:	Civilserve GmbH, Steinfeld

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1 Preface

The **GGU-CONTAM-RW** program allows modelling of contaminant transport in horizontal-plane, vertical-plane and axis-symmetrical groundwater systems according to the random walk method. A record containing the basic steady-state data must have been previously generated using the **GGU-SS-FLOW2D** program.

For evaluation and visualisation of analysis results, the **GGU-PLGW** program is available. It enable impressive, time-dependent animation or presentation of concentrations along sections through the system.

Data input is in accordance with conventional WINDOWS operations and can therefore be learned almost entirely without the use of a manual. Graphic output supports the true-type fonts supplied with WINDOWS, so that excellent layout is guaranteed. Colour output and any graphics (e.g. files in formats BMP, JPG, PSP, TIF, etc.) are supported. DXF files can also be imported by means of the integrated Mini-CAD module (see the **Mini-CAD** manual).

It is not the task of this manual to give an introduction to contaminant propagation modelling methods. For details, please refer to the literature.

The program system has been used in a large number of projects and has been thoroughly tested. No faults have been found. Nevertheless, liability for completeness and correctness of the program and the manual, and for any damage resulting from incompleteness or incorrectness, cannot be accepted.

The following general notes are important:

- The data forming the basis for contaminant transport modelling are records from steady-state modelling using **GGU-SS-FLOW2D**.
- Modelling is based on a rectangular array.

2 Licence protection and installation

In order to guarantee a high degree of quality, a hardware-based copy protection system is used for the **GGU-CONTAM-RW** program.

The GGU software protected by the *CodeMeter* copy protection system is only available in conjunction with the *CodeMeter stick* copy protection component (hardware for connection to the PC, "*CM stick*"). Because of the way the system is configured, the protected software can only be operated with the corresponding CM stick. This creates a fixed link between the software licence and the CM stick copy protection hardware; the licence as such is thus represented by the CM stick. The correct Runtime Kit for the CodeMeter stick must be installed on your PC.

Upon start-up and during running, the **GGU-CONTAM-RW** program checks that a CM stick is connected. If it has been removed, the program can no longer be executed.

For installation of GGU software and the CodeMeter software please refer to the information in the *Installation notes for GGU Software International*, which are supplied with the program.

3 Language selection

GGU-CONTAM-RW is a bilingual program. The program always starts with the language setting applicable when it was last ended.

The language preferences can be changed at any time in the "?" menu, using the menu item "**Spracheinstellung**" (for German) or "**Language preferences**" (for English).

4 Program concept

There are a number of numerical methods available for contaminant transport modelling:

- finite-element method,
- finite-difference method,
- particle tracking method (and in particular the random walk method).

The finite-element method is the most powerful of these, not only due to the flexible mesh design. This gives rise to the most basic question: why use particle tracking at all (here the random walk method in particular)? The reason is numerical dispersion, which is not related to physical dispersion. Numerical dispersion occurs where the finite-element method and the finite-difference method are used. The reason for numerical dispersion is the generally linear approximation approach within an element. Where the contaminant front is discrete, such an approach is no longer capable of precisely modelling this front. The contaminant front *smears*, an effect similar to physical dispersion and which is therefore known as numerical dispersion.

Particle tracking methods do not suffer from this problem. The particle tracking method is the simplest method. This method is incorporated in the **GGU-SS-FLOW2D** steady-state application in the shape of flow lines. The particle tracking method cannot consider either dispersion or diffusion effects. Only convection can be taken into consideration (movement of particles at groundwater speed). If, in addition, you wish to consider dispersion, diffusion, etc., the random walk method is generally used. The analytical solution of simple flow processes with contaminant transport leads to functions that correspond to a Gaussian distribution. This function can be modelled with a random generator, if sufficient attempts are made. This mathematical effect is utilised by the random walk method (random path method). The method first assumes propagation at groundwater flow velocity. This underlying velocity is superimposed upon by a dispersion (diffusion) velocity, the direction of which is determined by a random generator integrated in the application. In order to model the Gaussian curve mentioned above adequately, it is no longer sufficient to simply consider one contaminant particle. Rather, a multitude of particles is started and their courses recorded. This also has the result that the accuracy of the analyses increases with the number of started particles. Because of the integrated random generator, you will not get exactly the same result for any two different runs.

For contaminant propagation modelling a flow field is required (velocity magnitude and direction). **GGU-CONTAM-RW** gets this data from a record (e.g. "**plgw.da1**") generated in a previous analysis using the **GGU-SS-FLOW2D** application. It is therefore necessary to load this file first after opening the program. The flow field contained in this file remains constant for subsequent analyses.

Also typical for the random walk method is that analyses must be based on a rectangular mesh. This requirement does not conform to the flexibility of the triangular elements used in FEM (**GGU-SS-FLOW2D**), which forms the basis of the flow data for modelling. **GGU-CONTAM-RW** solves this problem by placing a rectangular array over the whole FEM mesh. It is possible to edit the rectangular array subdivisions within broad limits. In this system of triangular mesh and rectangular array, you now define the initial concentrations and any contaminant sources. The definition of time-dependent changes, such as performed in **GGU-CONTAM-FE** by means of polygon courses, is not possible using the random walk method. Once the initial concentrations have been defined, you must still specify how many particles to start. The program then assigns each particle a corresponding partial concentration. Now, during analysis, the paths of the contaminant particles are traced and the number of particles found in each rectangular cell counted for each time step. The summation of all partial concentrations within a cell then provides the total concentration that applies for that cell. These explanations demonstrate,

- that numerical dispersion cannot occur with this procedure;
- that the accuracy of the analysis is increased with the number of started particles;
- that the accuracy of contaminant distribution is not increased with the number of rectangular cells.

Because of the discrepancies between the triangular mesh and the rectangular array, the results from the rectangular cells are always converted to fit the triangular mesh. **GGU-CONTAM-RW** therefore generates two records:

- **Record 1 ("plgw_ras.plw")**
contains all results from the rectangular array. So, during subsequent evaluation using the **GGU-PLGW** application, a *rectangular triangle mesh* is displayed.
- **Record 2 ("plgw_fe.plw")**
contains the values from the rectangular array recalculated to fit the triangular mesh.

Besides the flow field, the **GGU-CONTAM-RW** program requires information on the initial contaminant distribution conditions at time $t = 0$. These so-called initial concentrations can be arbitrarily defined. If you do not define any values, the program will assume an initial concentration of "0" at all nodes.

Apart from the flow field, the "**RW vertical.da1**" file also includes the effective pore space n_{eff} , upon which steady-state modelling is based. This *steady-state* soil property (n_{eff}) cannot be edited in the **GGU-CONTAM-RW** application. If amendment of this value were allowed, the flow field would no longer correlate to the calculated potentials and the contaminant transport modelling would produce nonsensical results. However, you must enter the additional soil properties required for contaminant propagation modelling.

Besides additional soil properties the **GGU-CONTAM-RW** application also allows you to assign temporally constant concentration sources to individual nodes. Soil properties (contaminant transport modelling), as well as the allocation of initial concentrations and concentration sources to system nodes (so-called boundary values), can be saved in a separate file in order to make them available again for later analyses.

Generally, when modelling contaminant propagation in groundwater systems, a flood of result values is generated. The modelling results are saved in a file (generally "**_ras.plw**" and "**_fe.plw**") by **GGU-CONTAM-RW**. Contaminant propagation data cannot be evaluated using the **GGU-CONTAM-RW** program. The **GGU-PLGW** program is available for this purpose; it is described in a separate user-manual. For example, it is possible to evaluate the results using isolines, animations, sections or hydrographs.

The **GGU-CONTAM-RW** program is opened by conventional WINDOWS operations. The program is equipped with a large amount of error queries. Even highly nonsensical input will usually be detected by the program and an error message be displayed on the screen. Independently of this you should, for security reasons, intermittently save extensive input, if only to save renewed input in the case of a power cut.

5 Starting the program

After starting the program you will see two menus at the top of the initial window:

- File
- ?

After clicking on the "**File**" menu, a system processed with the **GGU-SS-FLOW2D** program can be loaded by means of the "**Load GW data**" menu item.

The processed system record is saved in **GGU-SS FLOW2D** using the ".**da1**" extension, in order to make it available for **GGU-CONTAM-RW**. The program function to be activated for this purpose can be found in **GGU-SS-FLOW2D** in the "**System/Analyse**" menu item.

Then, the menu bar will show seven menus:

- File
- Editor
- Concentrations
- Modelling
- Graphics preferences
- Page size + margins
- ?

After clicking on one of these menus, the so-called menu items roll down, allowing you access to all program functions.

The program works on the principle of ***What you see is what you get***. This means that the screen presentation represents, overall, what you will see on your printer. In the last consequence, this would mean that the screen presentation would have to be refreshed after every alteration you make. For reasons of efficiency and as this can take several seconds for complex screen contents, the **GGU-CONTAM-RW** screen is not refreshed after every alteration.

If you would like to refresh the screen contents, press either [**F2**] or [**Esc**]. The [**Esc**] key additionally sets the screen presentation back to your current zoom, which has the default value 1.0 corresponding to an A3 format sheet.

6 Short description

Since I know from personal experience that reading user-manuals is quite a chore, there will now follow a short description of the main program functions. After studying this section you will be in a position to model contaminant transport based on steady-state groundwater flow. You can learn about the details of the program in the subsequent chapters.

- In order to be able to use the system entered in your **GGU-SS-FLOW2D** groundwater flow program for contaminant transport modelling using the **GGU-CONTAM-FE** program, you must create a file in the **GGU-SS-FLOW2D** program with the file extension **".dal"**. You can create this file by going to **"System/Analyse"** and activating the check box **"Generate record for transient modelling"**.
- Start the **GGU-CONTAM-RW** program and using the menu item **"File/Load GW data"**, select the desired record of a flow system.
- Using the **"Editor"** menu you can define your **"Soil properties"**. A description of the individual constants can be found in the **"Info"** function field.
- The initial concentrations and any concentration sources are defined using the **"Concentrations"** menu. This is possible individually or in a section. You will be shown an info box with instructions. After being queried on whether you want to assign or delete concentrations, a dialogue box opens in which you must define whether it is an initial concentration or a concentration source. In the first instance, the concentration only applies at time $t = 0$ and is subsequently displaced, whilst a concentration source displays a constant concentration. If you do not define an initial concentration or a concentration source for any nodes, an initial concentration of **"0"** will be assumed.
- In **"Modelling/Preferences"**, you can apply preferences for the precision and extent of analysis by specifying the size of the array subdivisions. The smaller the array is defined, the more precise, but also time-intensive, the analysis. Moreover, by activating the analysis with the **"Element velocities"** option and deactivating the **"Exact velocities"** box you achieve fast, but less precise, analysis, whilst modelling using node velocities and the additional option of **"Exact velocities"** will give very precise analysis results.
- Commence contaminant transport modelling for your groundwater system with **"Modelling/Start"**. In the dialogue box that then opens you can enter the name of the output file for the rectangular array, as well as generating a record for the FEM mesh if you want an additional analysis based on the triangular array. The program then calculates a number of basic parameters. You then define an end time, the size of the time steps and the number of particles. A large number of particles also means more precise results but longer computing time.
- With the aid of the **GGU-PLGW** evaluation program, you can evaluate and display the modelling results. To facilitate this, load the file generated by **GGU-CONTAM-RW** (**"_ras.plw"**) or the file (**"_fe.plw"**) with the results recalculated on the basis of the FEM mesh in **GGU-PLGW**.

7 Contaminant propagation theory

7.1 Overview

The primary aim of contaminant transport modelling is the prognosis of future conditions on the basis of given initial data and, on occasion, pre-specified counter-measures.

Using a numerical analysis approach, even complicated systems can be investigated and assessed. Precise modelling of the natural conditions is difficult, due to the multitude of initial parameters required and the inhomogeneity of aquifers. Before any contaminant transport modelling, you should therefore ensure that your initial data justify this.

7.2 Mechanisms relevant to contaminant propagation

Five important mechanisms describe contaminant propagation in groundwater and must be entered as initial data for propagation simulation:

- **Convection**
is the migration of contaminants in the direction, and with the apparent flow velocity, of groundwater flow. This propagation mechanism is normally dominant in a flowing system, but is superimposed upon and influenced by others. Mathematically, this mechanism enters the differential equation in the shape of the apparent flow velocities u_x and u_y .
- **Dispersion**
includes the local deviation from the mean flow velocity. One differentiates between dispersion caused by the grain skeleton, which describes, amongst other factors, deviations in the flow course around the grain skeleton, and macro-dispersion, which is the dominant mechanism in wide-area contaminant propagation, e.g. in sand lenses and layering. This mechanism is described by the mathematical values of longitudinal (in flow direction) dispersivity α_L (m) and transverse (perpendicular to flow direction) dispersivity α_T (m).
- **Diffusion**
This type of propagation is determined by the concentration gradient. It is normally only effective in systems with extremely low velocity. In water at 10 °C, the diffusion coefficient D_m is $10^{-9} \text{ m}^2/\text{s}$.
- **Adsorption**
expresses the inhibition of contaminant migration due to adsorption onto the grain skeleton and is described by the sorption constant s_{orp} (-). The sorption constant is the product of grain density and the adsorption coefficient. Contaminant propagation is retarded by adsorption.
- **Decay**
As a result of physical, chemical and biological reworking, contaminants are eliminated from the groundwater. This process is described by the decay constant λ (1/s).

A mass balance equation and a space- and time-dependent, analysable differential equation results from these values:

Mass balance:

Increase in dissolved contaminant mass =

- net input by convection
- + net input by diffusion and dispersion
- + input from contaminant sources
- extraction from wells
- loss through decay reactions
- adsorption onto the grain matrix

7.3 The Courant criterion

The precision of all numerical procedures is influenced by the time step Δt . Precise results can be achieved with small time steps, but analysis time increases correspondingly. The optimum time step size can be derived from the "**Courant criterion**".

After starting analysis, the program examines the Courant criterion and suggests the determined time step.

8 Description of menu items

8.1 *File menu*

8.1.1 "Load GW data" menu item

To form the basis for your contaminant transport modelling, load the data of a steady-state ground-water model previously analysed using the **GGU-SS-FLOW2D** program using this menu item. This file has the default name of **".da1"**. In order to enable generation of this record by the **GGU-SS-FLOW2D** program, you must activate the **"Generate record for transient modelling"** check box in the **"System/Analyse"** menu item.

8.1.2 "System info" menu item

Upon opening this menu item you will be presented with information on the currently loaded system, the number of triangular elements and on the nodes.

8.1.3 "Load boundary values" menu item

Using this menu item you can reload a file containing boundary values which was previously defined and saved with the **"File/Save boundary values"** menu item, in order to further process this or to use it as the basis for contaminant transport modelling. The file contains the soil properties and the polygon courses, as well as the allocations of the polygon courses to the system nodes.

8.1.4 "Save boundary values" menu item

After selecting this function you can save the defined boundary values in order to have the data available again at a later date. The file with the suffix **"_ras.rdw"** contains the soil properties and the polygon courses, as well as the allocations of the polygon courses to the system nodes.

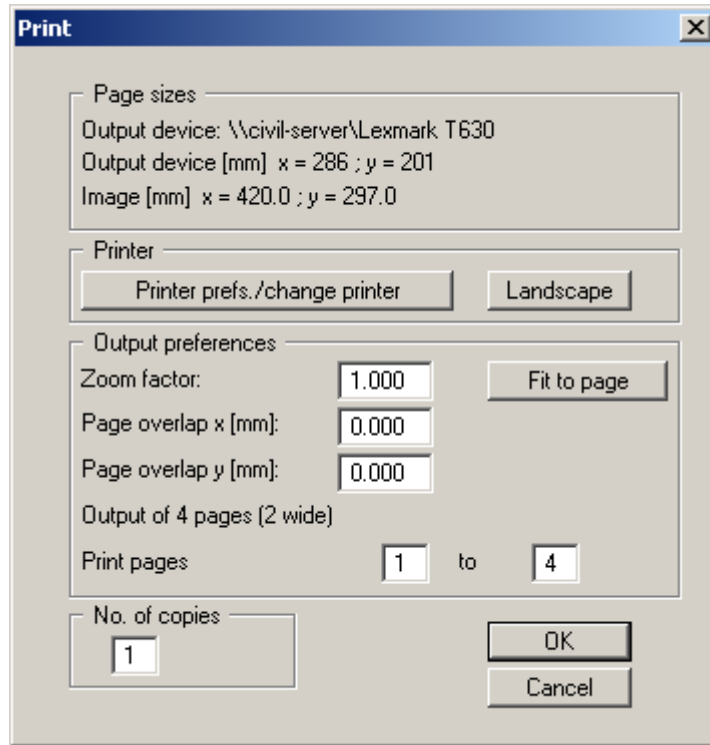
8.1.5 "Printer preferences" menu item

You can edit printer preferences (e.g. swap between portrait and landscape) or change the printer in accordance with WINDOWS conventions.

8.1.6 "Print and export" menu item

You can select your output format in a dialogue box. You have the following possibilities:


- **"Printer"**
allows graphic output of the current screen to the WINDOWS standard printer or to any other printer selected using the menu item **"File/Printer preferences"**. But you may also select a different printer in the following dialogue box by pressing the **"Printer prefs./change printer"** button.



In the upper group box, the maximum dimensions which the printer can accept are given. Below this, the dimensions of the image to be printed are given. If the image is larger than the output format of the printer, the image will be printed to several pages (in the above example, 4). In order to facilitate better re-connection of the images, the possibility of entering an overlap for each page, in x and y direction, is given. Alternatively, you also have the possibility of selecting a smaller zoom factor, ensuring output to one page ("**Fit to page**" button). Following this, you can enlarge to the original format on a copying machine, to ensure true scaling. Furthermore, you may enter the number of copies to be printed..

- **"DXF file"**
allows output of the graphics to a DXF file. DXF is a common file format for transferring graphics between a variety of applications.
- **"GGUCAD file"**
allows output of the graphics to a file, in order to enable further processing with the GGUCAD program. Compared to output as a DXF file this has the advantage that no loss of colour quality occurs during export.

- **"Clipboard"**
The graphics are copied to the WINDOWS clipboard. From there, they can be imported into other WINDOWS programs for further processing, e.g. into a word processor. In order to import into any other WINDOWS program you must generally use the *"Edit/Paste"* function of the respective application.
- **"Metafile"**
allows output of the graphics to a file in order to be further processed with third party software. Output is in the standardised EMF format (Enhanced Metafile format). Use of the Metafile format guarantees the best possible quality when transferring graphics.

If you select the **"Copy/print area"** tool  from the toolbar, you can copy parts of the graphics to the clipboard or save them to an EMF file. Alternatively you can send the marked area directly to your printer.

Using the **"Mini-CAD"** program module you can also import EMF files generated using other GGU applications into your graphics.

- **"MiniCAD"**
allows export of the graphics to a file in order to enable importing to different GGU applications with the Mini-CAD module.
- **"GGUMiniCAD"**
allows export of the graphics to a file in order to enable processing in the GGUMiniCAD program.
- **"Cancel"**
Printing is cancelled.

8.1.7 "Exit" menu item

After a confirmation prompt, you can quit the program.

8.1.8 "1, 2, 3, 4" menu items

The **"1, 2, 3, 4"** menu items show the last four files worked on. By selecting one of these menu items the listed file will be loaded. If you have saved files in any other folder than the program folder, you can save yourself the occasionally onerous *rummaging* through various sub-folders.

8.2.1 "Soil properties" menu item

After going to this menu item a system-specific dialogue box opens allowing input of the soil properties. The *steady-state* property n_{eff} imported from the **GGU-SS-FLOW2D** program can no longer be amended here.

No.	neff	alph_l	alph_t	Dm	Sorp	lambda
1	0.200	10.00	1.00	0.00E+0	0.00	0.00
2	0.050	10.00	1.00	0.00E+0	0.00	0.00
3	0.300	10.00	1.00	0.00E+0	0.00	0.00

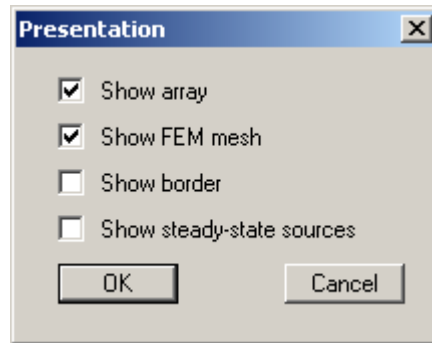
In the example above, three soils have been defined for the system (groundwater modelling with **GGU-SS-FLOW2D**). Enter the soil parameters relevant to contaminant transport in the input boxes:

- "Info"**
 This item provides information on the meaning of the parameters and the units used by them. Please ensure that you always use the same length and time units as those you applied to the permeability in the steady-state modelling in **GGU-SS-FLOW2D**. You can define the mass dimension at will; you must, however, use the same dimension for all parameters. This also applies to the subsequent definition of initial concentrations and concentration sources.
- "alph_l"**
 Enter the value of the longitudinal dispersivity α_l . This is a function of grain size and varies between a few centimetres (laboratory tests in sand) and over 100 metres (jointed rocks).
- "alph_t"**
 The transverse dispersivity α_t is generally a magnitude smaller than the longitudinal. In field tests, ratios around 0.01 were determined. Values of up to 0.3 are given in the literature.
- "Dm"**
 Enter the value of the diffusion coefficient D_m . This value only influences contaminant distribution at very low flow velocities. For water at 10°C, this value is $10^{-9} \text{ m}^2/\text{s}$.
- "Sorp"**
 Enter the value of the sorption constant $sorp$. The sorption constant is dimensionless and is the product of grain density and the adsorption coefficient.
- "lambda"**
 Enter the value of the decay constant λ .

8.2.2 "Visualisation format" menu item

Using the functions provided in this menu item you can alter the system and mesh display according to your wishes. This permits some control, but does not allow manipulation of the analysis.

By selecting this menu item, the following dialogue box appears:

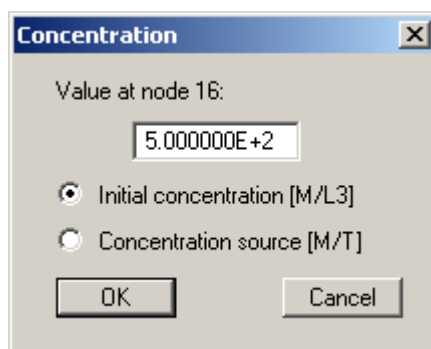


Activate the information you want to have displayed.

8.3 Concentrations menu

8.3.1 "Define individually" menu item

This menu item first generates a dialogue box, in which you specify the font size and the number of decimal places. After confirmation you can click on nodes to which you want to assign an initial concentration (> 0.0) or a concentration source, using the left mouse button. A concentration source is constant over time.



Please ensure that you always use the same length and time units as those you applied to the permeability in the **GGU-SS-FLOW2D** steady-state modelling. You can define the mass dimension at will; you must, however, use the same dimension for all parameters. This also applies to soil properties (see Section 8.2.1).

If you click a node with the right mouse button, any initial concentrations existing at the node are deleted.

8.3.2 "In section" menu item

In a similar manner to the previous menu item, you can assign initial concentrations or concentration sources to sections of the system. This is done by clicking four points in an anti-clockwise direction with the left mouse button. The concentration, which you enter into the following dialogue box, then applies to all nodes within the specified section.

Alternatively, it is possible to delete all defined initial concentrations, i.e. to set them to '0'.

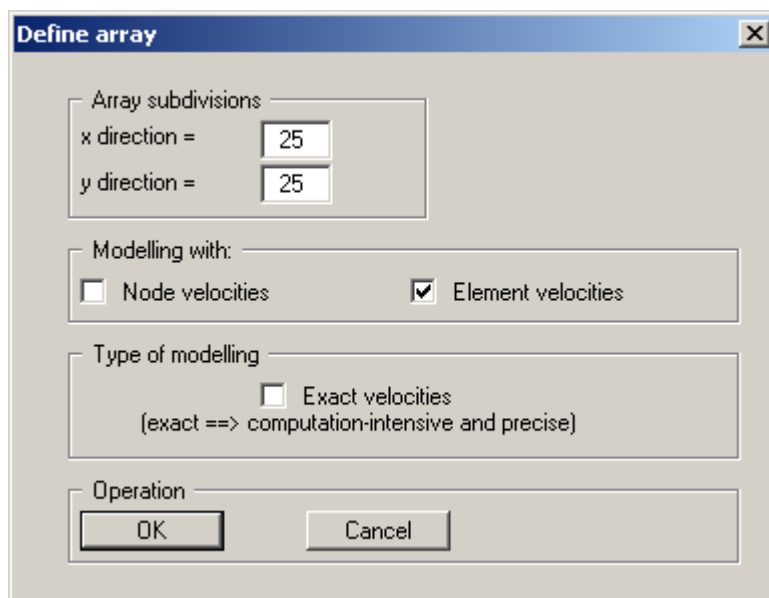
8.3.3 "From file" menu item

You can import concentrations from a previous analysis as initial concentrations. The first time step after the given time will be read.

8.4 Modelling menu

8.4.1 "Preferences" menu item

In this menu item's dialogue box, preferences can be defined for subsequent modelling.



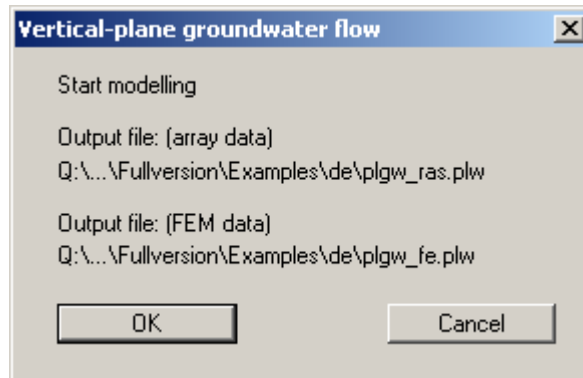
First, define the array subdivisions to stipulate the size of the cells. Read Section 4, "**Program concept**" to find out what influence the rectangular array has on the analysis.

You can also decide whether the analysis should be based on the node velocities or on the element velocities. Again, the principal difference here is in the analysis precision. The element velocity is constant for each element, whilst the node velocity is calculated from the mean of the velocities in the neighbouring elements. This increases the precision of the analysis, but also the time and effort required.

By activating the "**Exact velocities**" option the precision of the analysis is increased yet again. The program then determines the velocity of each contaminant particle at its current location. Otherwise, mean velocities are utilised for the corresponding cell.

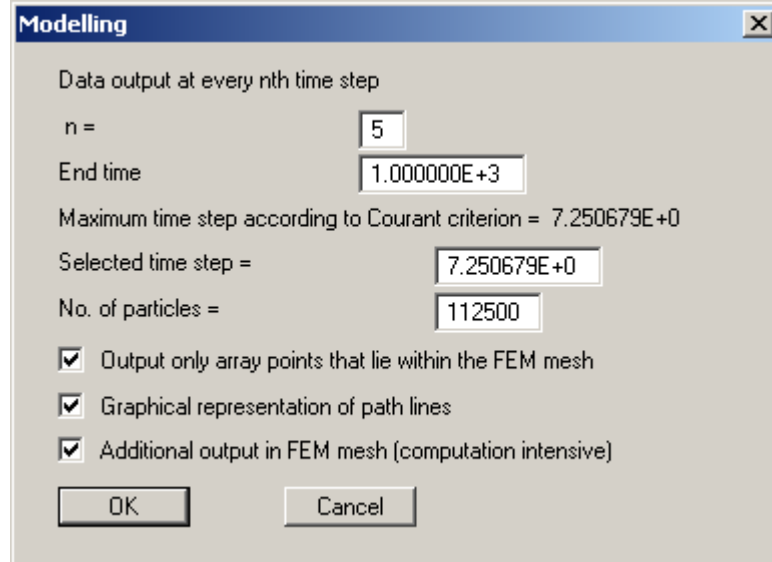
8.4.2 "Start" menu item

After clicking this menu item or, alternatively, by pressing [**F5**], a dialogue box opens showing the names of the output files.



- **Record 1 ("plgw_ras.plw")**
contains all results from the rectangular array. So, during subsequent evaluation using the **GGU-PLGW** application, a *rectangular triangle mesh* is displayed.
- **Record 2 ("plgw_fe.plw")**
contains the values from the rectangular array recalculated to fit the triangular mesh (FEM mesh).

Start your analysis by clicking "**OK**". A number of basic parameters are first calculated. The following dialogue box is subsequently displayed:



Generally, a flood of result values is generated during analysis. You can define an interval (i) for data output. In addition, you must also enter the end time for the analysis.

The precision of all numerical procedures is influenced by the size of the time step. More precise results can be achieved with small time steps, but modelling time increases correspondingly. The maximum allowable time step size can be derived from the "**Courant criterion**". You can modify this time value, but should not increase the proposed time step.

You then enter the number of particles to be started and whose paths are to be traced. By activating the "**Graphical representation of path lines**" check box the path lines can be traced on the computer screen during analysis (very impressive, but also increases computation time).

Finally, you have the opportunity of suppressing output of data for recalculation of the array data to the triangular mesh (FEM mesh).

After selecting the "**OK**" button the calculation proper will begin. A dialogue box with a "**Cancel**" button will inform you of analysis progress. If you select this button, analysis will not cease immediately, but instead you can edit specific program data and then carry on the analysis.

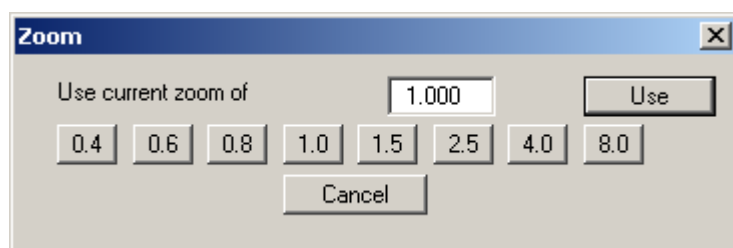
The record is generated for the evaluation application during modelling. If, after commencing modelling, you open the **GGU-PLGW** program, you can check and evaluate the current results while modelling is still in progress. The "**Animation**" function is particularly impressive here; it can be executed parallel to the running modelling process.

8.5 Graphics preferences menu

8.5.1 "Refresh and zoom" menu item

The program works on the principle of *What you see is what you get*. This means that the screen presentation represents, overall, what you will see on your printer. In the last consequence, this would mean that the screen presentation would have to be refreshed after every alteration you make. For reasons of efficiency and as this can take several seconds for complex screen contents, the screen is not refreshed after every alteration.

If, e.g., after using the zoom function (see below), only part of the image is visible, you can achieve a complete view using this menu item.



A zoom factor between 0.4 and 8.0 can be entered in the input box. By then clicking on "Use" to exit the box the current factor is accepted. By clicking on the "0.4", "0.6", etc. buttons, the selected factor is used directly and the dialogue box closed.

It is much simpler, however, to get a complete overview using [Esc]. Pressing [Esc] allows a complete screen presentation using the zoom factor specified in this menu item. The [F2] key allows screen refreshing without altering the coordinates and zoom factor.

8.5.2 "Zoom info" menu item

By clicking two diametrically opposed points you can enlarge a section of the screen in order to view details better. An information box provides information on activating the zoom function and on available options.

8.5.3 "Pen colour and width" menu item

In order to enhance the clarity of the graphics you can edit the pen settings e.g. for the initial concentration. You can edit the pen widths for the elements shown in the dialogue box; by clicking on the button with the element designation you can also edit the pen colours.

On *monochrome printers* (e.g. laser printers), colours are shown in a corresponding grey scale. Graphic elements employing very light colours may be difficult to see. In such cases it makes sense to edit the colour preferences.

8.5.4 "Legend font selection" menu item

With this menu item you can switch to a different true-type font. All available true-type fonts are displayed in the dialogue box.

8.5.5 "Mini-CAD toolbar" and "Header toolbar" menu items

Using these two menu items you can add free text to the graphics and add lines, circles, polygons and images (e.g. files in formats BMP, JPG, PSP, TIF, etc.). The same pop-up menu opens for both menu items, the icons and functions used are described in more detail in the **Mini-CAD** manual provided. The differences between the Mini-CAD and Header CAD are as follows:

- Objects created with **Mini-CAD** are based on the coordinate system (generally in metres), in which the drawing is produced, and are shown accordingly. You should use the "**Mini-CAD toolbar**" when you wish to add information to the system (for example, labelling of slope inclinations or the location of any foundations).
- Objects created with the **Header CAD** are based on the page format (in mm). This makes you independent of the coordinate system and keeps you in the same position on the page. You should select the "**Header toolbar**" if you wish to place general information on the drawing (company logo, report numbers., plan numbers, stamp etc.). Once you have saved the header information to disk (see **Mini-CAD** user manual), you can load it into completely different systems (with different system coordinates). The saved header information will appear in exactly the same position on the page, which greatly simplifies the creation of general page information.

8.6 Page size + margins menu

8.6.1 "Auto-resize" menu item

This menu item provides a to-scale visualisation, in both x and y coordinates, of the system and result graphics. If you have previously altered the image coordinates using "**Page size + margins/Manual resize (mouse)**" or "**Page size + margins/Manual resize (editor)**", you can quickly achieve a complete view using this menu item. This function can also be accessed using the [F9] function key.

8.6.2 "Manual resize (mouse)" menu item

You can use the coordinates of a section of the visualisation as the new image coordinates by marking the desired area with the mouse, pressing the left mouse button and holding the [Ctrl] and [Shift] keys. The scales of the x- and y-axes are adjusted accordingly. If the previous proportions (scale x-direction/scale y-direction) need to be retained, the "**Proportional section**" check box must be activated.

Alternatively, you can simply "**Redefine origin**" of the visualisation. The previous scale preferences are not affected by this.

8.6.3 "Manual resize (editor)" menu item

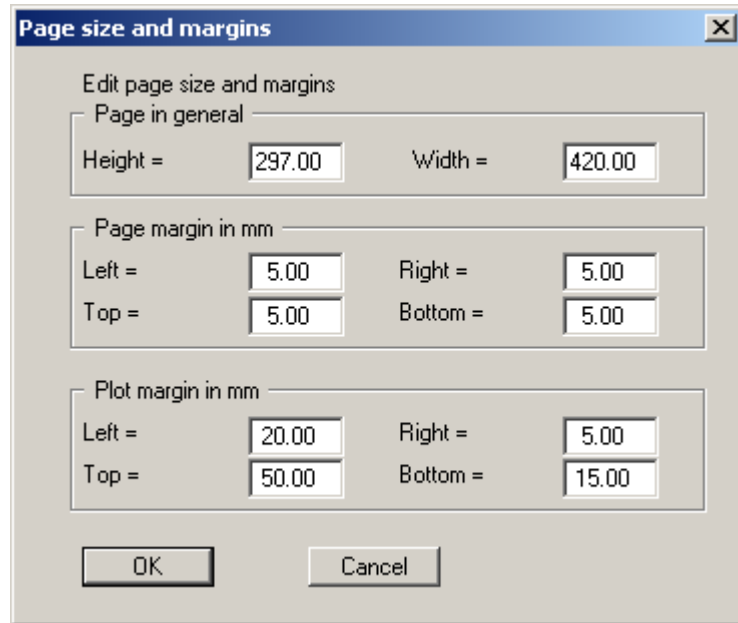
You can alter the image coordinates by direct numerical input in a dialogue box. This allows precise scale input. The coordinates refer to the *drawing area*. This can be defined in the "**Page size + margins/Page size and margins**" menu item by means of the plot margins (see Section 8.6.5).

8.6.4 "Font size selection" menu item

You can edit font sizes for labelling the various drawing elements.

8.6.5 "Page size and margins" menu item

The default page set-up is A3 when the program is started. You can edit the page format in the following dialogue box.



- **"Page in general"** defines the size of the output sheet. The A3 format is set as default. The program automatically draws thin cutting borders around the page, which are required when using a plotter on paper rolls.
- **"Page margin"** defines the position of a frame as a distance to the margins. This frame encloses the subsequent diagram.
- The **"Plot margin"** define a set distance between the page margin and the actual *drawing area* in which the graphical evaluation of your input is presented.

8.7 ? menu

8.7.1 "Copyright" menu item

You will see a copyright message and information on the program version number.

The "**System**" button shows information on your computer configuration and the folders used by **GGU-CONTAM-RW**.

8.7.2 "Maxima" menu item

A message box displays the program's default maximum number of nodes and elements for the FEM mesh, and the particle and array subdivisions.

8.7.3 "Help" menu item

The **GGU-CONTAM-RW** online-help is opened using an installed browser (e.g. MS Internet Explorer). The help function can also be accessed using the [**F1**] function key.

8.7.4 "GGU on the web" menu item

Using this menu item you can access the GGU Software website: www.ggu-software.com. Keep in touch with new program versions and the regular *download* offers.

If you would like to be automatically notified about program innovations, please register for the Newsletter in our Knowledge Base. Go to the following website: <http://kbase.civilserve.com>.

8.7.5 "GGU support" menu item

This menu item takes to the GGU-Software [Support area](http://www.ggu-software.com/support) at www.ggu-software.com.

8.7.6 "What's new?" menu item

You will see information on program improvements in comparison to older versions.

8.7.7 "Language preferences" menu item

This menu item allows you to switch the menus and the graphics from German to English and vice versa. To work in German, deactivate the two switches "**Dialoge + Menüs übersetzen (translate dialogues, menus)**" und "**Graphiktexte übersetzen (translate graphics)**".

Alternatively, you can work bilingually, e.g. with German dialogue boxes but with graphic output in English. The program always starts with the language setting applicable when it was last ended.

9 Tips

You can scroll the screen with the keyboard using the cursor keys and the **[Page up]** and **[Page down]** keys. By clicking and pulling with the mouse, with **[Ctrl]** pressed, you activate the zoom function, i.e. the selected section will fill the screen. Use the mouse wheel to zoom in or out of the screen view or to pan.

In addition, scale and coordinates of the system graphics (drawing area within the plotting margins) can be altered directly using the mouse wheel. The following mouse wheel functions are available:

Change system graphics (new values can be checked in "Page size + margins/Manual resize (editor)")::

- **[Ctrl]** + mouse wheel up = enlarge system graphics (change of scale)
- **[Ctrl]** + mouse wheel down = shrink system graphics (change of scale)
- **[Shift]** + mouse wheel up = move system graphics up
(change in system coordinates)
- **[Shift]** + mouse wheel down = move system graphics down
(change in system coordinates)
- **[Shift]** + **[Ctrl]** + mouse wheel up = move system graphics right
(change in system coordinates)
- **[Shift]** + **[Ctrl]** + mouse wheel down = move system graphics left
(change in system coordinates)

Change screen coordinates:

- Mouse wheel up = move screen image up
- Mouse wheel down = move screen image down
- **[Alt]** + **[Ctrl]** + mouse wheel up = enlarge screen image (zoom in)
- **[Alt]** + **[Ctrl]** + mouse wheel down = shrink screen image (zoom out)
- **[Alt]** + **[Shift]** + mouse wheel up = move screen image right
- **[Alt]** + **[Shift]** + mouse wheel down = move screen image left

By double-clicking the left mouse button on legends or Mini-CAD objects, the editor for the selected object immediately opens, allowing it to be edited.

Some of the function keys are assigned program functions. The allocations are noted after the corresponding menu items. The individual function key allocations are:

- **[Esc]** refreshes the screen contents and sets the screen back to the given format. This is useful if, for example, you have used the zoom function to display parts of the screen and would like to quickly return to a complete overview.
- **[F1]** opens the online-help.
- **[F2]** refreshes the screen without altering the current magnification.
- **[F5]** opens the menu item "**Modelling/Start**".
- **[F9]** activates the menu item "**Page size + margins/Auto-resize**".

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