STORM Help Index

How to ...

start with STORM (brief description).

Commands

used abbreviations

List of abbreviations

You can find futher information in the index and by the help of the implemented search function or in the manual.

If you got any other problems which can not be solved with the help or the manual we offer 90 days of free support.

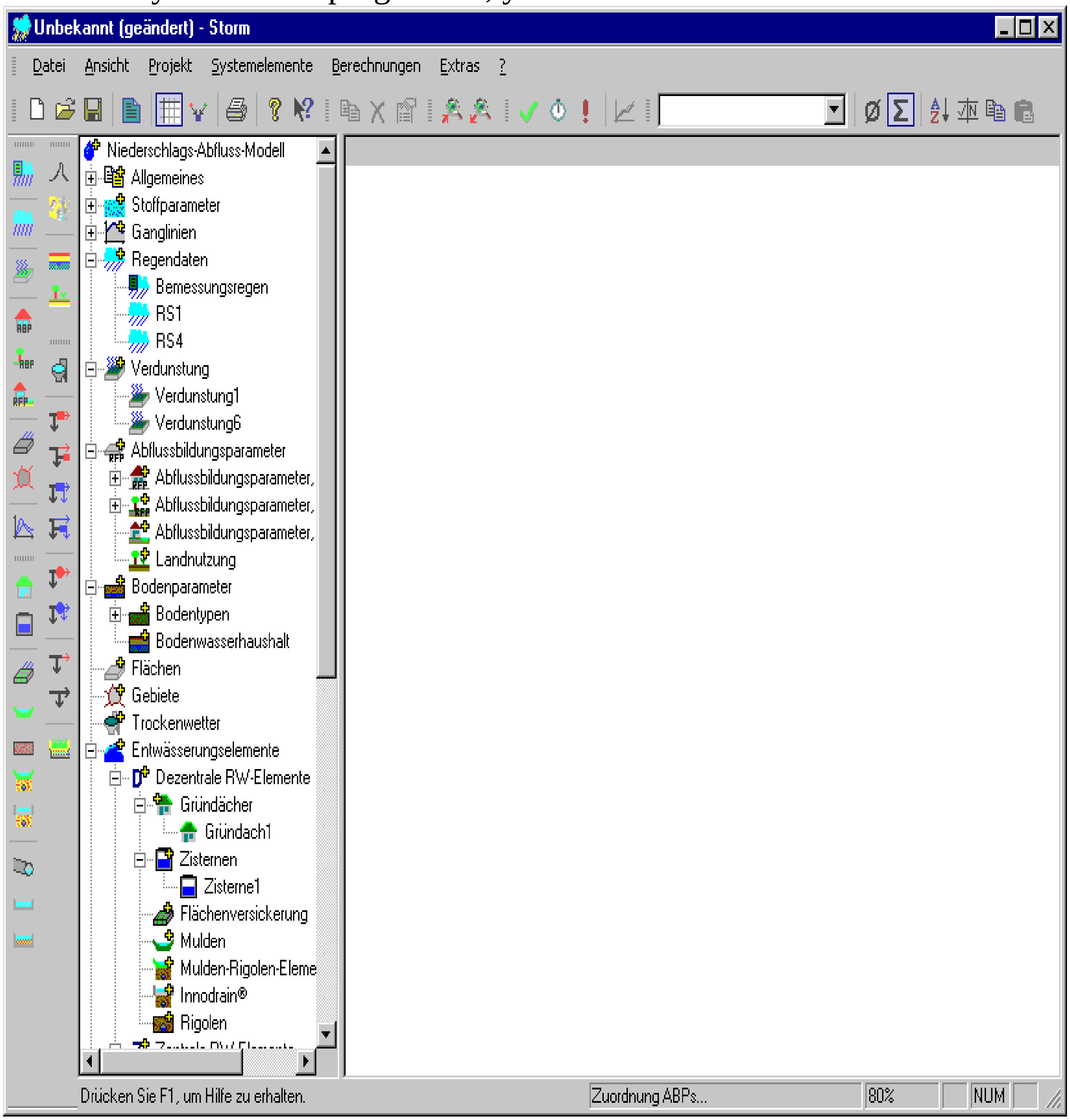
Please send us a fax or e-mail with name, adress, customer number, version number of the program, operating system and a description of the problem to 03342/359529 or info@sieker.de. We will answer your request as fast as possible.

For further support we offer service contracts.

Getting Started Quickly

If you're working with STORM for the first time, we'd like to offer you a quick introduction to the programme.

Whenever you start the programme, you'll see this screen.

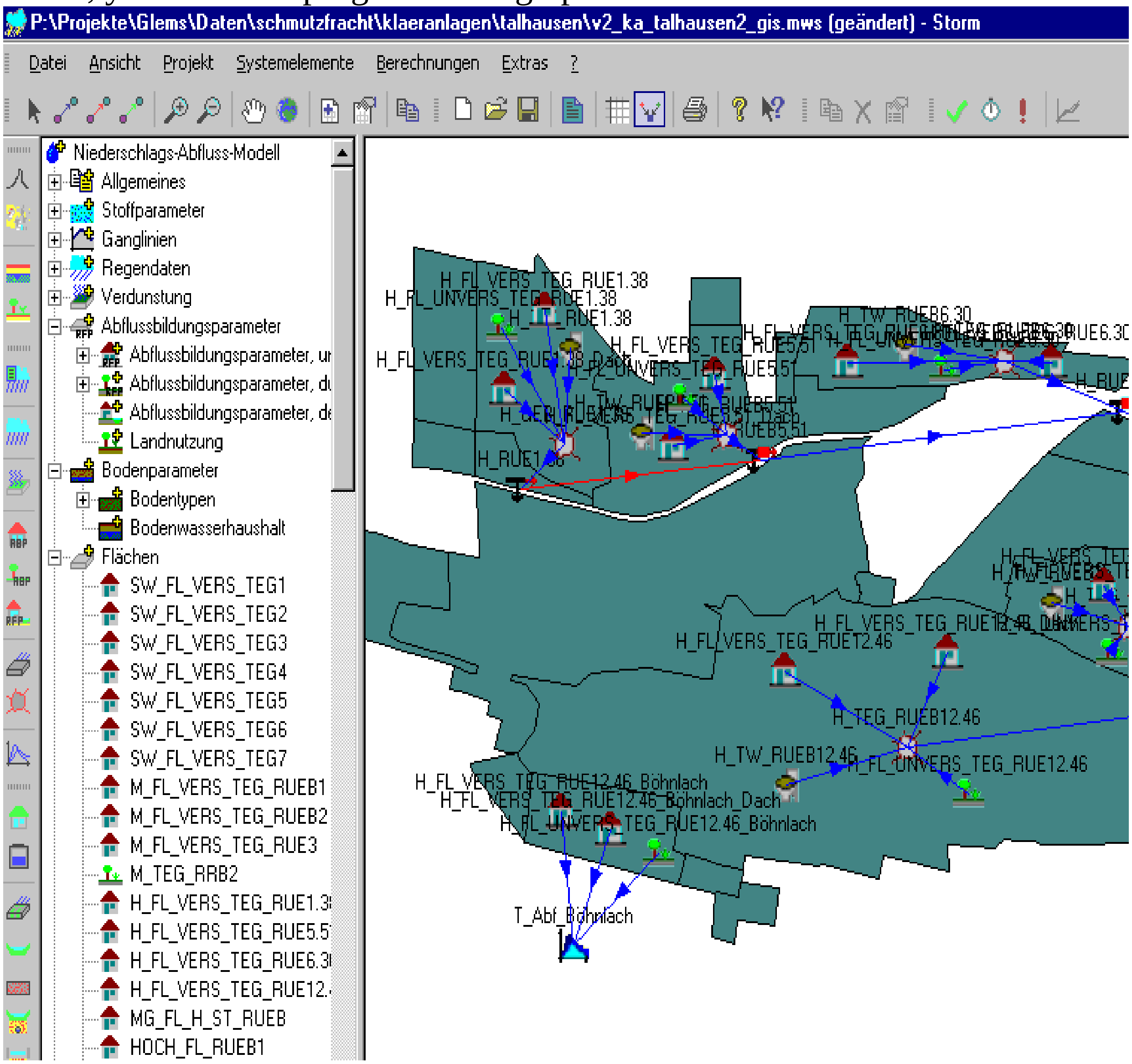


You'll find:

the pulldown menus underneath the title bar

the tree structure view of the elements the table view on the right next to the tree structure.

If you click on the Graphic View button or select "Graphic" from the View Menu, you'll see the programme in graphic mode.



Several toolbars make working with STORM easier:

[General](#)
[Table View](#)
[Graphic View](#)
[Create New Combined Sewage Elements](#)
[Create New Stormwater Elements](#)
[Create New Elements](#)
[Create New Natural Elements](#)
[Shapefile View](#)
[Export/Import ArcView](#)

Edit Object
Computations
We would like to present you the various possibilites of STORM for entering elements for stormwater management by means of a sample project.

1.1 General

Since the beginning of the 1980's, increasing attention has been given to the fact that drainage technology in regards to infiltration of precipitation discharges represents a close-to-nature, ecologically oriented technique for the disposal of stormwater with clear advantages in comparison to conventional drainage practices of combined and separate sewage systems. With consistent advancements in infiltration technology, the trough-infiltration trench (TRINT) system was developed at the Institute for Water Management at the University of Hanover, Berlin.

1.1.1 Why is a New Concept Necessary?

For stormwater running off of sealed surfaces, recognized technological standards and practices suffice if sufficiently large combined sewers with stormwater overflow tanks and stormwater retention tanks are planned. This way, the function of urban drainage is secure and satisfactory to the public. Regarding watercourses, however, only partial protection is ensured. The watercourses' hydraulic and polluting load is reduced in comparison to unthrottled discharges, but does not avoid, in spite of the structural and technical expenditure, the considerable costs of sewage channels and water treatment facilities. In addition, the problems of space and location are difficult to overcome.

The wastewater treatment facilities, generally designed to manage two to three times the dry weather discharge volume, are practically overloaded during each rain event causing poor treatment performance. This poses a disadvantage to the receiving waters.

Groundwater, which is replenished naturally by infiltrating stormwater and slowly enters the watercourses, does not undergo improvement by conventional drainage systems. It is becoming clear that former procedures entail many ecological disadvantages despite their high and ever rising costs. Stormwater is merely treated as a waste only to be disposed of. According to new urban planning conceptual viewpoints, this provides excellent new opportunities to construct aesthetically pleasing structures in keeping with the drainage-technical necessity.

In many cases, the possibility exists to recharge groundwater with stormwater with the aid of on-site infiltration systems. For short-term stormwater storage, grassy swales can be utilized to allow the water to infiltrate. Very often, however, the condition of the ground is such that the soil permeability does not allow complete infiltration of rainwater runoff. This can be remedied by the swale-infiltration trench (TRINT) system. The stormwater seeping through the top soil layeris buffered by a permeable trench structure. The water can then seep into the surrounding soil, discharged via a throttle to a receiving surface water body or delivered to other types of drainage components.

Coupling of the swales and trenches results in a swale-infiltration-trench system, whose conceptual layout can be adapted to local conditions. This adaptability is very effective in tailoring a system suited to a region's storage capability and needs and allows for sound management of the stormwater. The various combinations possible with the swale-infiltration trench system using gutters, ditches, swales and ponds gives much flexibility to the design of aesthetic appearance and high standard. It is even possible to connect cisterns for stormwater utilisation.

1.1.2 Range of Application for On-site Stormwater Management

- Rehabilitation Using New Drainage Technology Existing sewage networks are overloaded in part due to the increase of sealed surfaces. The "usually" applied rehabilitation strategy using large-profile collecting tanks can be avoided if a catchment area is disconnected from the sewer system and drained by means of on-site methods, such as the TRINT system.

- New Urban Developments
  There have been countless projects completed where it was only possible to build a new development through the application of on-site stormwater management because the existing sewer system or receiving waters would not have been able to have accepted additional stormwater runoff. The discharge throttling produced by the on-site process is so effective that the existing sewer system downstream is sufficient and further construction is not necessary.
  Even discharge restrictions for low-capacity receiving waters on the part of the authorities can be retained with the system.

- Active Waterbody Protection with Combined Sewer Systems
  According to the German standards in ATV A128, if stormwater overflow from combined sewer systems into receiving water bodies is anticipated, the drainage system must be equipped with stormwater overflow and retention tanks. This provision serves an important function for waterbody protection, but is still insufficient or has not been realised in many areas. Although the responsible authorities are aware of the effects the excess pollution loading from these tank facilities have on the receiving waters, the realisation in minimising the environmental impact has been slow, due in part to the high costs of constructing and operating additional facilities. Here, the TRINT system offers a valuable alternative by avoiding combined sewage overflows to receiving waters and by relieving and steadying the operation of wastewater treatment plants.

1.1.3 Long-term Simulation

Computation methods, which operate with a block or model rain, require statistical pre-processing of the precipitation (rain series, model rain processes, etc.). In contrast, this pre-processing is not required when using a long-term simulation, because statistical analyses are carried out using the results of the simulation.

When using long-term simulations, the German ATV working group “Hydrology of Urban Drainage” (ATV Arbeitsgruppe 1.2.6) suggests the following:

During ***long-term simulation***, the runoff processes in sewer systems, which result from a sequence of single rain events, are simulated mathematically. A prerequisite for such a simulation is that the input loading data used for the model calculations consist of rain gauge readings actually measured in their natural chronological progression. The possibility exists to change the chronological sequence of different events if the events are statistically independent of each other. However, the intensity sequence of the individual events may not be altered.

During long-term simulation, individual events or the entire precipitation continuum from a number of continuously measured rain data from several years are utilized. In keeping with the “long-term” concept, the measured rain data base used for the simulation should be ***at least 10 years*** in length.

Depending on the range of the data taken from the continuum as input for the simulation model, two categories of long-term simulation are differentiated:

Long-term Series Simulation and

Long-term Continuum Simulation

A more detailed description of these terms is given in the work report of the ATV working group 1.2.6.

Stormwater management based on drainage technology using the TRINT systems, which is oriented according to water management objectives and conceptualised with certain overflow characteristic values, throttle discharges, and storage volumes, requires that a **continuum simulation** be carried out:

At the end of a precipitation-discharge event, components of the TRINT system are still partially impounded, which are further discharged at the beginning of the following dry weather phase. The emptying time of the storage volumes may be very long, particularly if the throttling capacity is low and the storage elements have large impounding volumes. If an additional precipitation event occurs during the emptying phase of the storage element, only the unimpounded volume, not the entire volume, can be utilized.

Special attention must be given to the case when the networked trench system must also accept discharges from another system in addition to the rainwater runoff of its own drainage catchment. Optimization of the storage capabilities, taking into consideration these local specific aspects, is only possible by means of a continuum simulation.

1.1.4 Function and Modelling

This documentation includes a description of the model and various facilities along with a brief documentation from the programme package STORMę.
The short documentation for STORMę gives an overview of the programme setup and the input dialogues. In addition, the individual input parameters, which are sometimes given as defaults, are described.
The model description covers all the technical aspects to STORMę. This includes modelling system elements and hydrological components as well as describing the simulation process from pre-dimensioning to statistical analysis.

1.1.5 What's New?

1.1.5.1 User Interface

In Version 3.1

- Complete newly designed Windows-32Bit-User Interface with editing and breakdown of system elements and their data in **table** and **graphical** form.
- Develop and make changes to drainage systems graphically.
- Integrates all programme components (data input, pre-dimensioning, long-term simulation) into one programme. No more time-consuming switching between different programmes.
- Option of presenting calculation results in the programme with or without creating a report. Transfer tables to other programmes (such as MS Excel) via the clipboard.
- Option to create result reports in Rich-text format.
- Includes Microsoft Word-Viewer for Windows 95/NT to view the result reports.

In Version 4.0

- New graphical user interface based on MapObjects
- Integrate and layer coordinate-exact GIS data with shapefiles (ArcView), AutoCad or CAD files in .dxf and .dwg format, and aerial photos or graphics in .bmp, .tif and .jpg format.

Export / Import drainage element shapefiles to and from ArcView and other GIS systems.

1.1.5.2 Computation

In Version 3.1:

- New system elements:
- Takes permeable surfaces into consideration.
- Stormwater retention tanks: pre-dimensioning according to German ATV A117 standards
- Cisterns: pre-dimensioning according to WILHELM
- Area-neutral approach to calculating the runoff formation, resulting in time savings with larger systems.
- Retention can be taken into account with connecting pipes.
- No restrictions regarding how elements can be linked; for example, trenches can be connected to (centralised) infiltration swales.
- Interactive pre-dimensioning for single system elements.
- Hydrograph readouts of runoff and water levels possible at each location in the system.

In Version 4.0:

- New system elements:
- Surface infiltration with regard for paved surfaces
- Green roofs
- Innodrain©
- Storage cascades for taking the runoff concentration in larger catchments into account
- Connection to Hystem-Extran possible by creating wave files.
- Outputs a precipitation hydrograph in .csv format.
- The output of single events for rain gauges and runoff makes it possible to complile precipitation and runoff statistics.

1.2.1 Preparation

This chapter describes the software's system requirements and explains what to do before you install the programme onto your computer.
If you are familiar with navigating through Windows and using a mouse, you will be able to work with this programme. If you'd like to learn more about those subjects, please consult the manuals to your operating system.
By pressing the <?> key, you can get help at any time if you aren't sure how to continue.

1.2.1.1 Hardware and Software Requirements

Minimum system requirements for successful operation of the programme:

- PC with a 80486 processor or better
- At least 16 MB RAM, 32 MB recommended
- Graphics card with compatible monitor
- Hard drive with at least 20 MB of free disk space
- Serial port (V.24/RS232) or PS/2 port with mouse
- CD-ROM drive for installing the programmes STORMę and WordView

Installed operating system: Windows 95 (with system update), 98 or higher, Windows NT 4.0 or higher

1.2.1.2 Registering STORM© / License Agreement

Please take a moment to read the license agreement. Read all the provisions of the license agreement carefully and thoroughly before you open the package. By opening the package, you thereby accept all provisions of the license agreement. Should you not be in agreement, please return the unopened CD-ROM envelope and all other articles delivered with the STORM© package to the manufacturer of the programme for a refund of the purchasing price.

Since you received STORM© directly from the manufacturer, you are already a registered owner and are authorized to obtain customer service consultation. We will inform you about new products and updated programme versions.

1.2.2 Installation

The installation of the programme is carried out with the help of the installation programme SETUP.EXE, which is found on the CD-ROM. When you insert the CD, the installation programme is started automatically.

To install the programme on Windows NT, you must be authorized as administrator or as a main user on the computer! We recommend you login as administrator before installing the programme on the operating system.

Follow the on-screen instructions displayed by the installation assistant. Please take a moment to read the license agreement.

1.2.3 Hotline

For problems that can't be solved with the help of the user guide, there is a free hotline available to you for 90 days after programme purchase. Just send us a fax with your name, address, customer nummer, programme version number, operating system and a description of the problem to +49 (0)3342/359529 or send us an e-mail to info@sieker.de. We will assist you as soon as possible. This service is also available after the 90 days have expired. Please ask us about service contracts.

1.2.4.1 Using the Mouse

TRINTSIM is menu driven using a mouse with at least two buttons. The left mouse button allows the selection of program functions in pull down menus as well as the use of symbols and tool bar buttons.

The context menu is displayed by means of the right mouse button. The context menu contains frequently used commands, which can be applied to the item selected by the mouse.

A double click with the left mouse button on an element in the element tree displays or hides the branch extensions corresponding to that element (see Figure 2.1). The same action is carried out by click the symbols ⊞ or ⊟ (as in the Windows Explorer).

1.2.4.2 Programme User Interface and Display Control

The program user interface is arranged according to the newest versions of Microsoft Word and Excel and divided into the following sections:

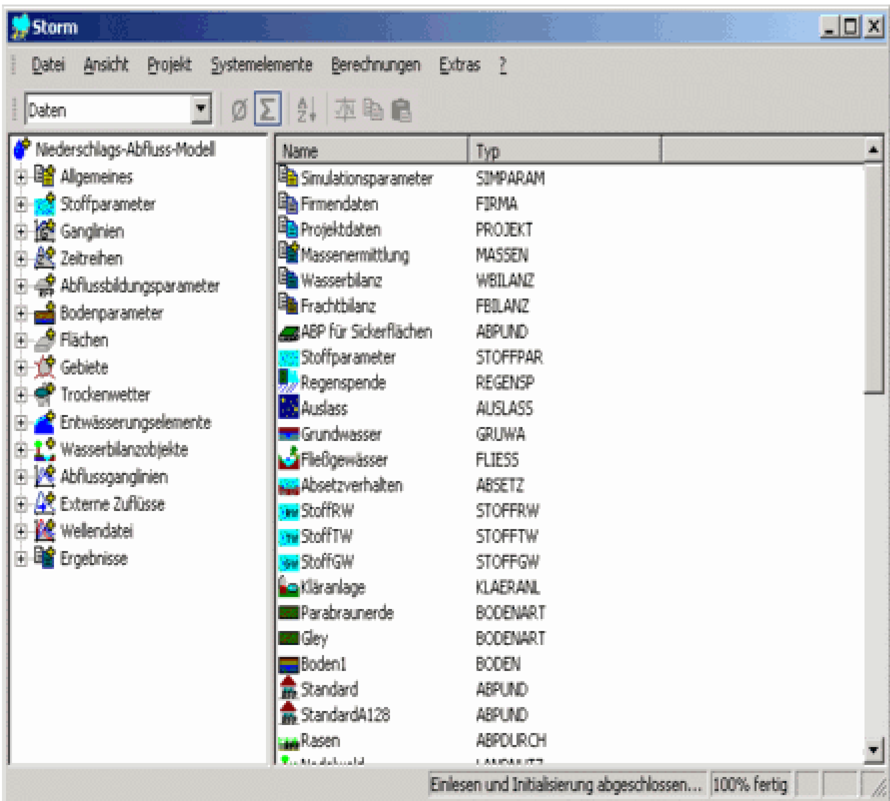


Figure 1-1: User interface sections for STORM© in Table Mode

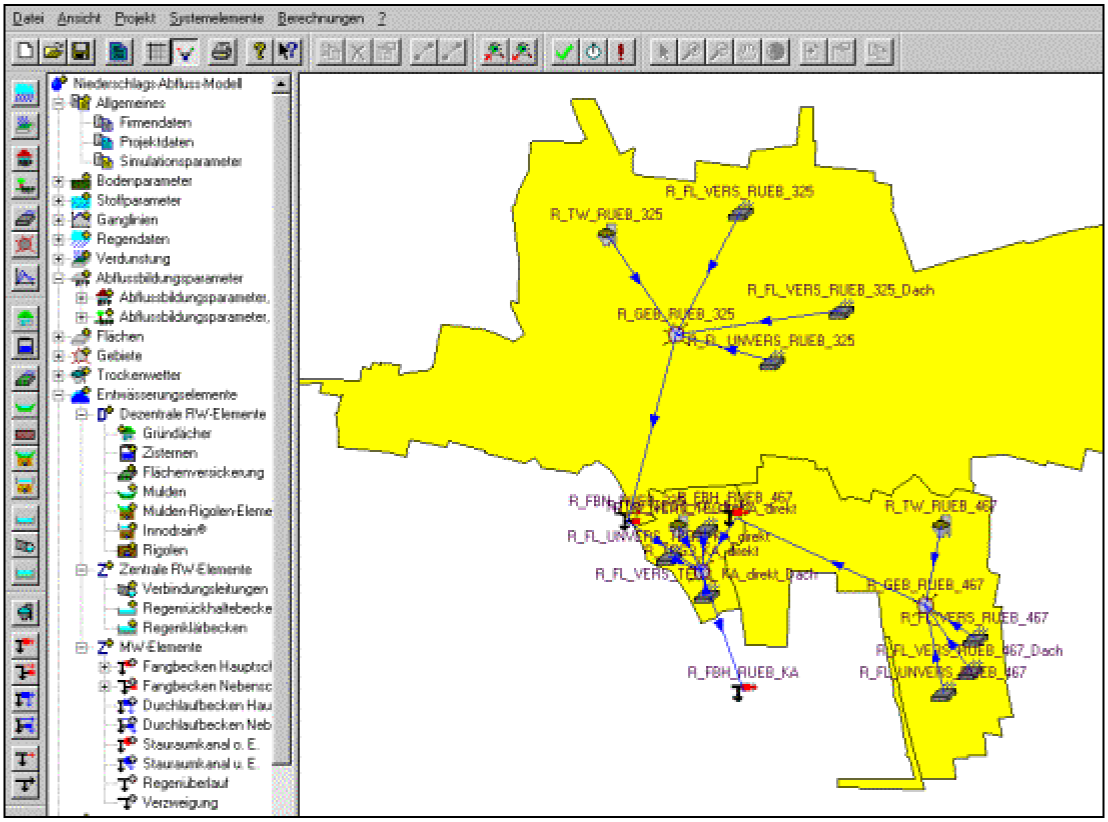
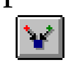
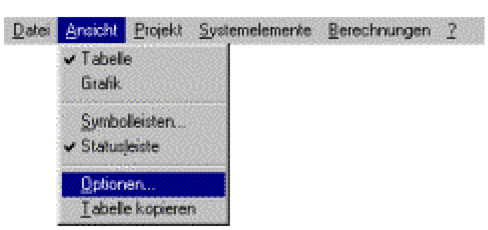


Figure 1-2: User Interface sections for STORM© in Graphic Mode

STORM© also includes the option of a graphical interface, which you can activate by via the menu or by clicking the  button in table view.
This graphical interface is changed as of STORM© 2000 and now based on Map Objects® by ESRI. It is now possible to layer bitmaps such as aerial photos, as well as CAD graphics from AutoCAD® accurately to the actual coordinates. The drainage elements are then positioned in the proper location. Drainage elements can be exported as shapefiles (.shp) to the GIS Programme ArcView (by ESRI) to be edited further, and then reimported or reloaded.
If the mouse pointer is briefly held on any symbol or button without clicking, a tip about the function appears. These tips, called **QuickTips**, can be switched off in the dialog window "Toolbar configuration."



The toolbars can be moved around on the screen freely. All toolbars and the status bar can be turned on and off in the "View" pulldown menu.

Figure 1-3: The View Menu with the menu item for configuring toolbars

The **element tree** shows the items of the rain-runoff model. In the **data table** the properties pertaining to the chosen element are displayed in a table. Since many elements store large quantities of data which may not all be reasonably shown in a table, the possibility exists to select which data categories are to be listed using the **list field**.

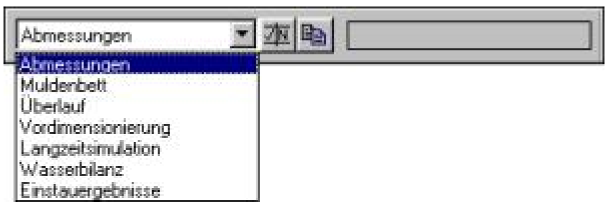


Figure 1-4: List field with categories of the "swale" element

 With this button or by using the menu item "Options..." in the "Project" pulldown menu, you determine which table columns of the data category are to be displayed.

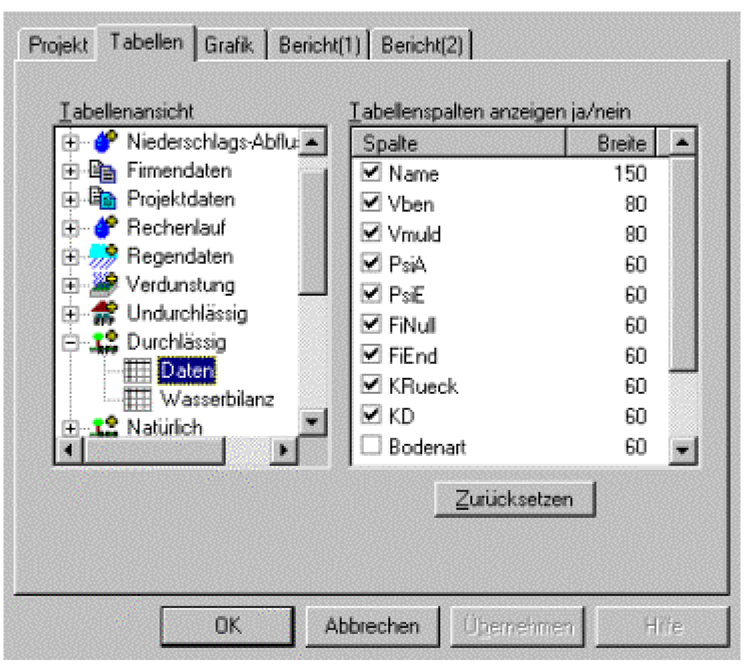


Figure 1-5: Dialog box "View Options" with check boxes for each table column of the "Dimensions" category for swale data

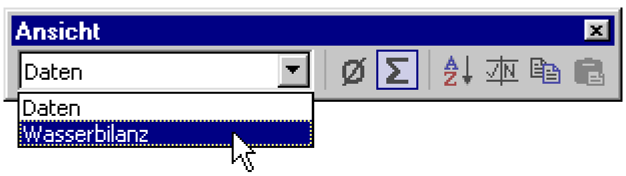
1.2.4.3 Tree Structure View

The tree structure view displays all system elements in an overview.
Elements of the same type are combined together.
The manipulation of this tree structure basically corresponds to that in other Windows programmes like Windows Explorer. Single branches of the tree can be shown or hidden by clicking on the node.
The type of element chosen in the tree structure determines the portrayal of the element data in the Table View. For a better overview, the name of the chosen element is displayed in the toolbar as well.
Double-clicking on an element opens the properties dialog, where you can input or change data.
Clicking the right mouse button (while an element is selected) makes a small context menu appear. Use this to add new elements, delete elements, or call up the properties dialog.

1.2.4.4 Table View

Name	Vben [mm]	Vmuld [mm]	PsiA [-]	PsiE [-]
Flachdach	2.00	0.00	1.00	1.00
Steildach	0.30	0.00	1.00	1.00
Hof/Wegeflächen	0.70	1.80	0.00	0.75
Straße	0.50	1.80	0.00	0.95

The Table View shows a selection of element data in table form. Which data are displayed depends on the chosen element type in the tree structure view and the chosen table view.
You can change the element type by selecting another element or the appropriate group in the tree structure view.
You can select a different table view for the same element type by selecting a different table in the View Toolbar.



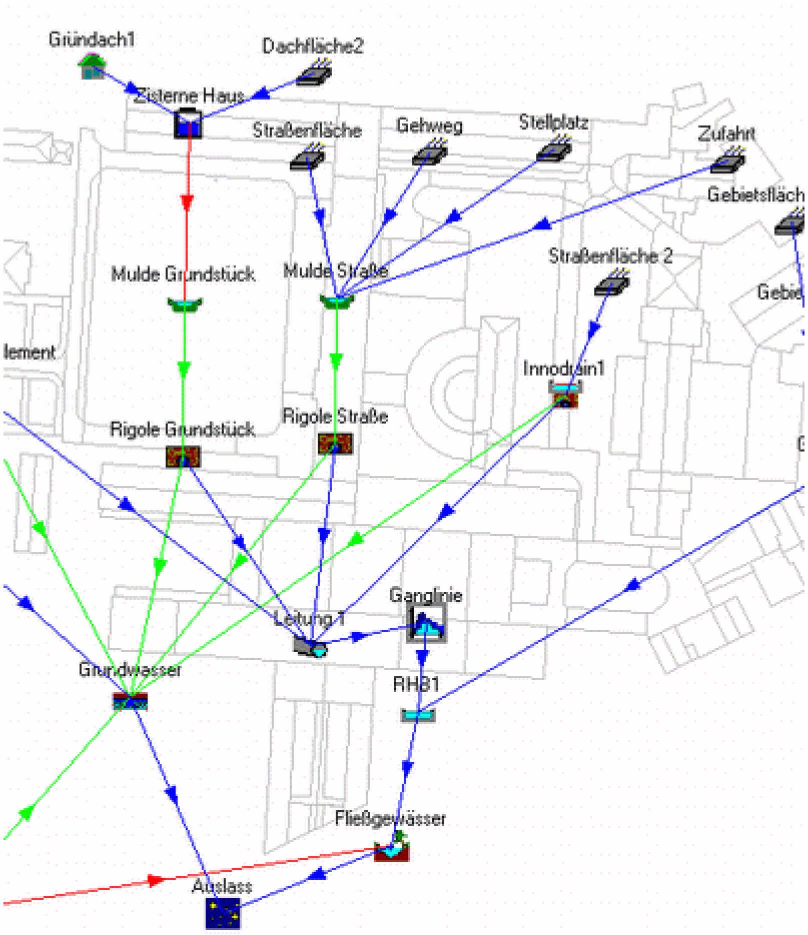
There is a particularity when displaying impoundage results. Here only the results for one element at a time are shown. You can select a different element via the tree structure view.
You can show or hide single columns with the menu command "Viewing Options."
With the menu command "Copy Table" you can copy content from the table being shown to the windows clipboard and then to other programs such as Microsoft Excel.

1.2.4.5 Table of Drainage Elements

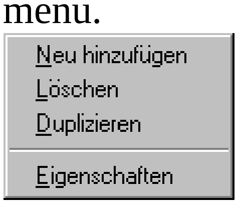
Name d.Element...	Ziel Ablauf	Ziel Versick.	Ziel Überl.	X-Koordinate [m]	Y-Koordinate ...
Fläche1	Mulde1			-22,50	42,50
Mulde1		Rigole1	Leitung 1	-20,49	30,23
Fläche2	Mulde2			7,50	42,50
Mulde2		Rigole1	Leitung 1	-8,98	30,56
Fläche3	Mulde3			22,50	42,50
Mulde3		Rigole1	Leitung 1	0,57	30,72
Rigole1	Gang1	Grundwasser	Gang1	0,41	21,58
MRE1	Fließgewässer	Grundwasser	Fließgewässer	-22,50	0,00
Innodrain1	Fließgewässer	Grundwasser	Fließgewässer	-22,50	0,00
Grundwasser	Auslass			4,45	12,97
Gang1	Leitung 1			-8,49	20,43
Leitung 1	Fließgewässer			-20,08	21,41
Gründach1	Fließgewässer		Fließgewässer	-22,50	0,00
Zisterne1			Fließgewässer	-22,50	0,00
Gebiet1	Fließgewässer			-22,50	0,00
Fließgewässer	Auslass			-19,92	13,09
Kläranlage	Auslass			0,00	0,00
Auslass				0,00	0,00

Connections
In the table you can see the drainage elements and their drainage destinations.
If an element has several destinations, it has various discharge destinations that result from infiltration, overflow or (throttle) discharge.
You can copy this table and transfer it to a word processor or spreadsheet. (also see Table View) *Water Balance*
By changing the view in the toolbar's list field to "Water Balance," you can get an overview of all elements.

1.2.4.6 System Graphic View



The System Graphic View shows the main elements of the drainage system. It makes it easier to have an overview of the system you've created and offers the possibility for graphical editing.
The graphic shows the connections (discharge, overflow, infiltration) of the individual objects.
Double-clicking on an element opens the properties dialog.
Clicking on an element with the right mouse button calls up the context menu.



With this context menu you can choose whether you want to add a new element or whether you want to delete or duplicate the selected element.

If you click on an object and hold down the left mouse button, you can drag it to any new position. The connection arrows are automatically updated.

1.2.4.8 Printing a Graphic

Printing graphics directly is unfortunately not possible in this version of the implemented Map Objects module by ESRI. Therefore, an alternative way must be selected in order to print. We hope that this is corrected in the next version.
The following options make it possible for you to indicate how the document should be printed. Of course, you can also copy the file to the clipboard and paste it into another programme from there.

Graphics Programme

The graphics programme's path and executable file is indicated here. The default is mspaint.exe in the Windows directory. Additionally, you can choose whether you want to start the programme and whether printing should occur automatically with parameters set by you.

Graphic Filename
Here you determine the filename for the graphic. This will be saved in .bmp format as a pixel graphic and can be read by all common graphics programmes.

1.2.4.9 Help

 Help can be called up by clicking on this button or by selecting the menu item "Help Topics" in the "?" pulldown menu. In the dialog you can view help text organised by topic or you can search by keyword.
The menu item "Info about Storm ..." in the "?" pulldown menu serves to check the currently installed programme version.

 This button in the toolbar, as well as the question mark button at the right in the title of the dialog window initialises the context-oriented input help.
Click the input field for which you need help (also see Figure 3-25) or press the function key while inputting.

1.3 Elements and Dialogs

 Zu allen vorhandenen und neu angelegten Objekten in STORM© existiert ein Eigenschaftsdialog, der sich durch Doppelklick auf das Objekt, über das Kontextmenü oder diese Symbolschaltfläche öffnet.
Die Schaltfläche „Ok“ beendet den Dialog und übernimmt die eingegebenen Daten als neue Eigenschaften des Objekts. Die Schaltfläche „Abbruch“ schließt ebenfalls das Dialogfenster, jedoch werden alle Eingaben verworfen. Wenn im Anschluss an die Erfassung der Daten eines Objektes die Eigenschaften eines weiteren Objektes eingegeben werden sollen, ist die Schaltfläche „Übernehmen“ zu nutzen. Im Gegensatz zur Schaltfläche „Ok“ bleibt das Dialogfenster offen, um nach einem einfachen Klick auf ein anderes Objekt im Objektbaum dessen Eigenschaften zur Bearbeitung anzubieten.
Durch Anklicken eines Karteikartenreiters wird die entsprechende Karteikarte in den Vordergrund gestellt.
Wenn nach der Eingabe oder Änderung von Objekteigenschaften ein neues Objekt ausgewählt wird, ohne zuvor die Schaltfläche „Übernehmen“ anzuklicken, erfolgt eine Sicherheitsabfrage, ob die Änderungen gespeichert werden sollen!

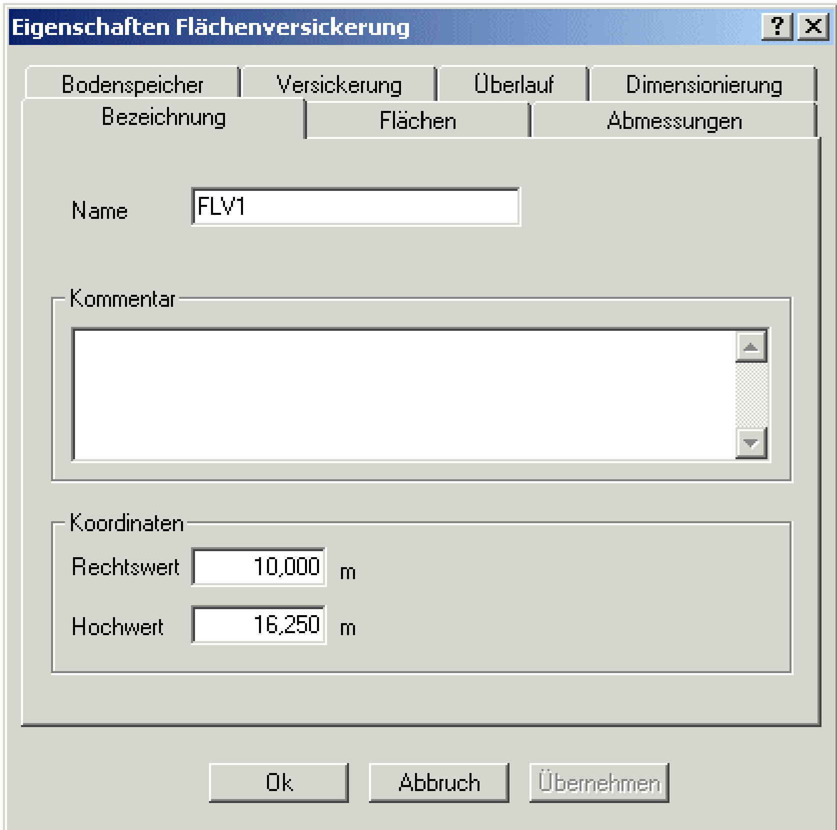


Abbildung 1-13: Eigenschaftsdialog mit der Karteikarte „Bezeichnung“ mit Koordinaten

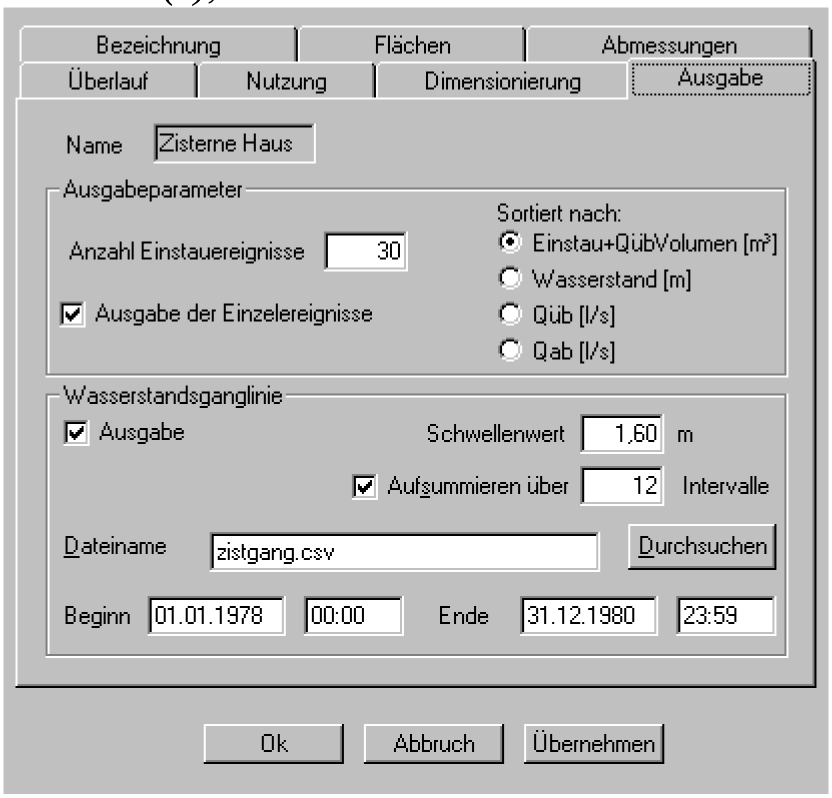
Mit Ausnahme der allgemeinen Objekte (Firmen- oder Projektdaten) und des Regenschreibers existiert zu allen Objekten eine Karteikarte „Bezeichnung“ im Eigenschaftsdialog, in der neben dem Namen des Objektes auch Kommentare und zum Teil Koordinatenangaben erfasst werden.

Um Wiederholungen zu vermeiden werden im Abschnitt 1.3.0 zuerst die mehrfach auftretenden Karteikarten erläutert und anschliessend die für jedes Element spezifischen Dialoge beschrieben.

1.3.0 Allgemeine Dialoge

System Elements: Output Tab

Cisterns, Green Roofs, Swales, Trenches, Swale-Trench Elements, Innodrain(c), Stormwater Retention Tanks



In the properties dialog for the system elements "Cisterns", "Green Roofs", "Swales", "Trenches", "Swale-Trench Elements", "Innodrain(c)" and "Stormwater Retention Tanks", you'll find the "Output" tab.
Here you can set the type and scope of the output.

Output Parameters

In the "Output Parameters" section, the number of significant impound events is set. The value determines the scope of the report as well as the basis for statistical analysis.

Depending on frequency, anywhere from 20-40 impound events is sensible.

By clicking the "Output of events" checkbox, you can set whether the impound events should be output to the report or not.

Furthermore, you have the option to sort the events according to the following criteria:

Impound & overflow volume

Water level
Qüb [l/s]
Qab [l/s]

Runoff Hydrograph

In the "Runoff Hydrograph" section, you can activate the output of a water level hydrograph for the element by clicking on the checkbox.

With the threshold value you can suppress the output of zero-values, i.e. periods without a water level, by entereing the smallest value to be reported. For example, you can enter 0.1 in order to have all events with water levels greater than 0.1 m written to the file.

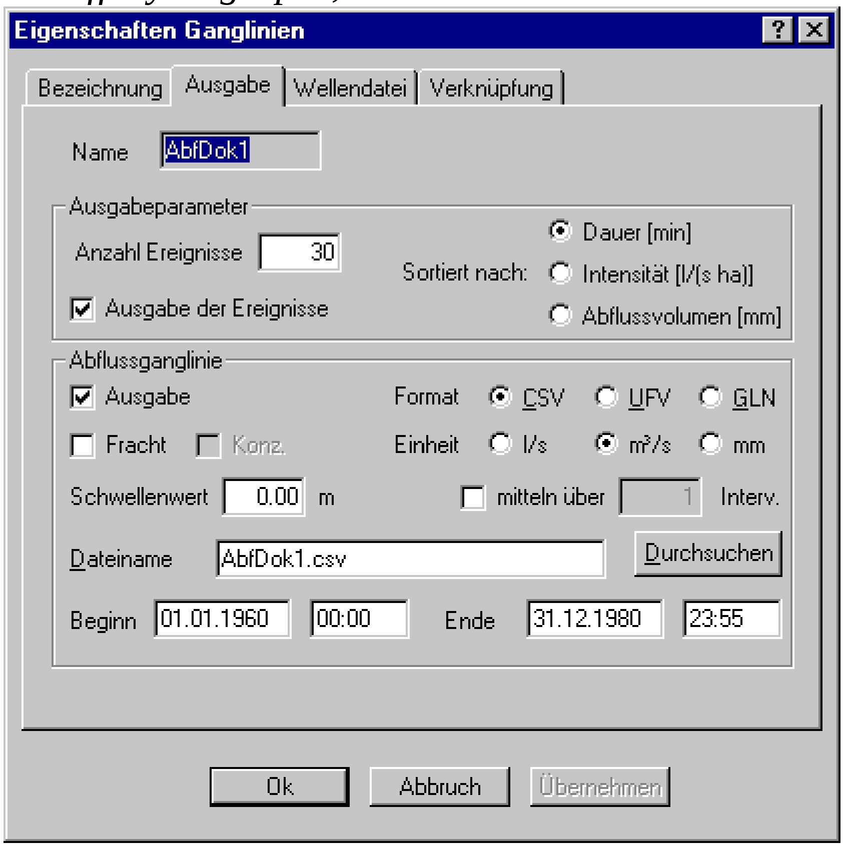
By clicking on the "Average over __ intervals" checkbox, you can set whether the values should be summed up over a certain interval. This makes sense if the wavefile shall be created over a long time period, since the output file will otherwise be too large.

Enter a filename for outputting the .csv file (values with a comma as a separator) or set the location and name of the report with the "Browse" button.

The timestep for outputting the file can be set with a beginning and end in the last line.

System Elements: Output Tab

Runoff Hydrographs, Catchments



In the properties dialog for the system elements "Runoff Hydrographs" and "Catchments" you'll find the "Output" tab.
Here you can set the type and scope of the output.

Output Parameters

In the "Output Parameters" section, the number of significant impound events is set. The value determines the scope of the report as well as the basis for statistical analysis.

Depending on frequency, anywhere from 20-40 impound events is sensible.

By clicking the "Output of events" checkbox, you can set whether the impound events should be output to the report or not.

Furthermore, you have the option to sort the events according to the following criteria:

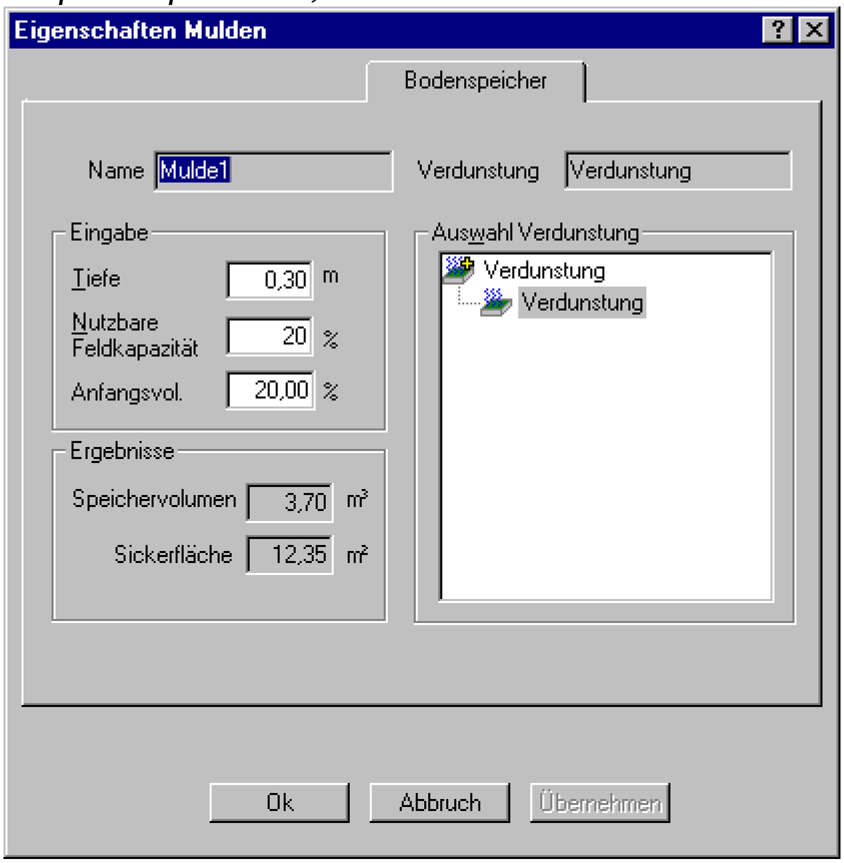
Impound & overflow volume

Water level
Qüb [l/s]
Qab [l/s]

Runoff Hydrograph
In the "Runoff Hydrograph" section, you can activate the output of a water level hydrograph for the element by clicking on the checkbox.
With the threshold value you can suppress the output of zero-values, i.e. periods without a water level, by entereing the smallest value to be reported. For example, you can enter 0.1 in order to have all events with water levels greater than 0.1 m written to the file.
By clicking on the "Average over __ intervals" checkbox, you can set whether the values should be summed up over a certain interval. This makes sense if the wavefile shall be created over a long time period, since the output file will otherwise be too large.
Enter a filename for outputting the .csv file (values with a comma as a separator) or set the location and name of the report with the "Browse" button.
The timestep for outputting the file can be set with a beginning and end in the last line.

System Element Properties: Ground Storage Tab

Surface Infiltration, Swale



In the properties dialog for swales you'll find the "Ground Storage" tab.

Input

In the "Input" section, you can indicate the depth of the swale bed in m and the usable field capacity nFK (in %). The defaults values are 0.3 m for the swale bed and nFK = 20%. The initial volume can also be given as a percentage.

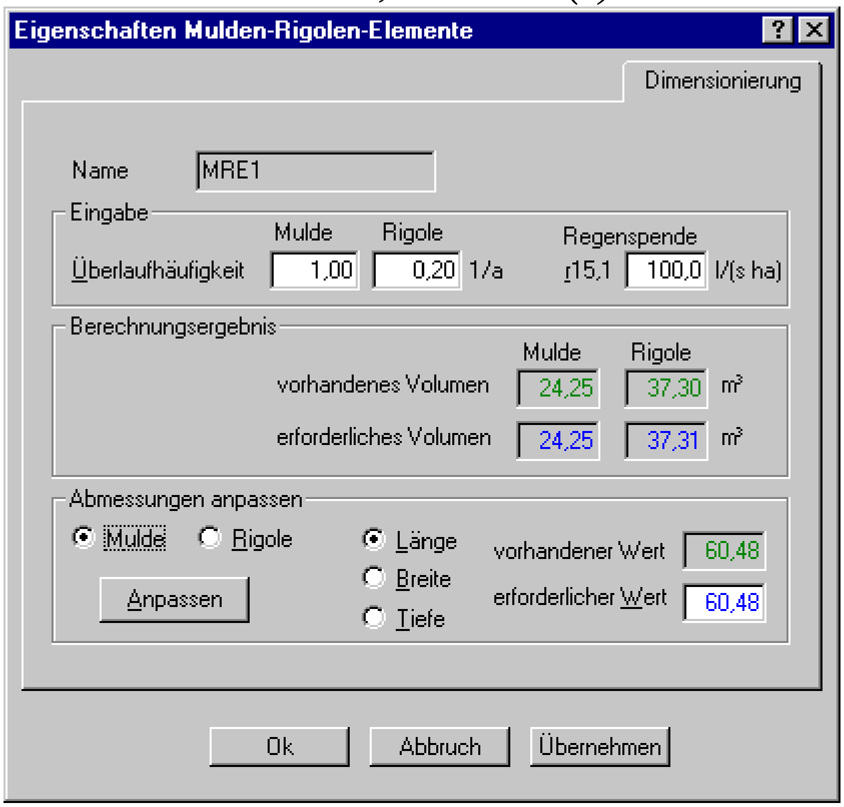
Results
In the "Results" section, the automatically calculated storage volume and the max. infiltration surface (upper edge of the swale impound).

Choose Evaporation

In the "Choose Evaporation" section, you can select an evaporation element. The evaporation affects the emptying of the ground storage after the end of the rain event.

System Elements Properties: Dimensioning

Swale-Trench Elements, Innodrain (c)



In the properties dialog for the system elements "Swale-Trench Element" and "Innodrain(c)" you'll find the "Dimensioning" tab.

Input
In the "Input" section, you can enter overflow frequencies, separately for both the swale and the trench, per year in n/a. Additionally, the preset rain intensity 15.1 for a 15-minute storm is indicated in the "rain intensity" dialog. You can change this value if necessary. Default values are n=1.0 for swales or n=0.2 for trenches and 100 l/(s*ha).

Computation Results

In the "Computation Results" section, the available volumes and volumes required due to rain intensity and indicated overflow frequency are shown. If the existing volume is not enough, the output is shown in red, otherwise in green.

Dimensioning occurs in accordance with German guidelines ATV-Arbeitsblatt A138.

Fit Dimensions

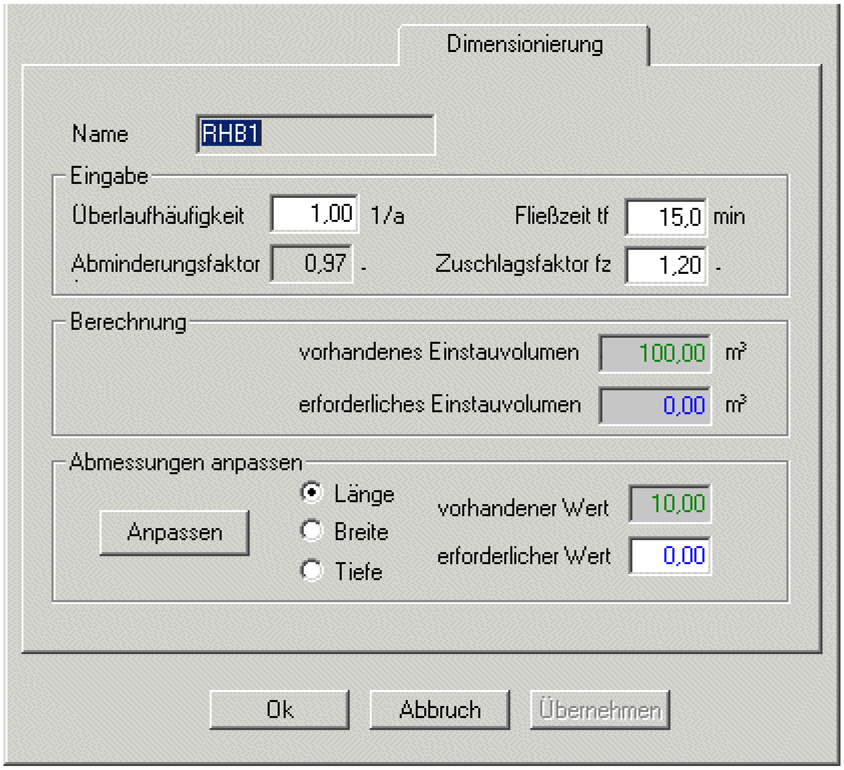
In the "Fit Dimensions" section, you can adjust the volume of the swale or trench to the required volume separately. The required volume is determined by dimensioning.

First, select the swale or trench. Then decide whether you want to adjust length, width or depth. In the "existing value" vield, the current value is shown. In the "required value" field, the newly calculated value is shown. This is the value that is required in order to provide enough storage volume. If the existing value is not enough, the output is shown in red, otherwise in green.

By clicking on the "Fit" button, the adjustment is made; i.e. the current value is saved.

System Elements Properties: Dimensioning Tab

Swales, Trenches, Stormwater Retention Tanks



In the properties dialog for swales, trenches and stormwater retention tanks, you'll find the "Dimensioning" tab.

Input

In the "Input" section you can enter the *Overflow Frequency* per year in n/a.

Computation

In the "Computation" section, the existing volume and the volume required due to rain intensity and indicated overflow frequency are shown. If the existing volume is not enough, the output is shown in red, otherwise in green.

Dimensioning occurs in accordance with the German guidelines in the worksheet ATV A138.

Fit Dimensions

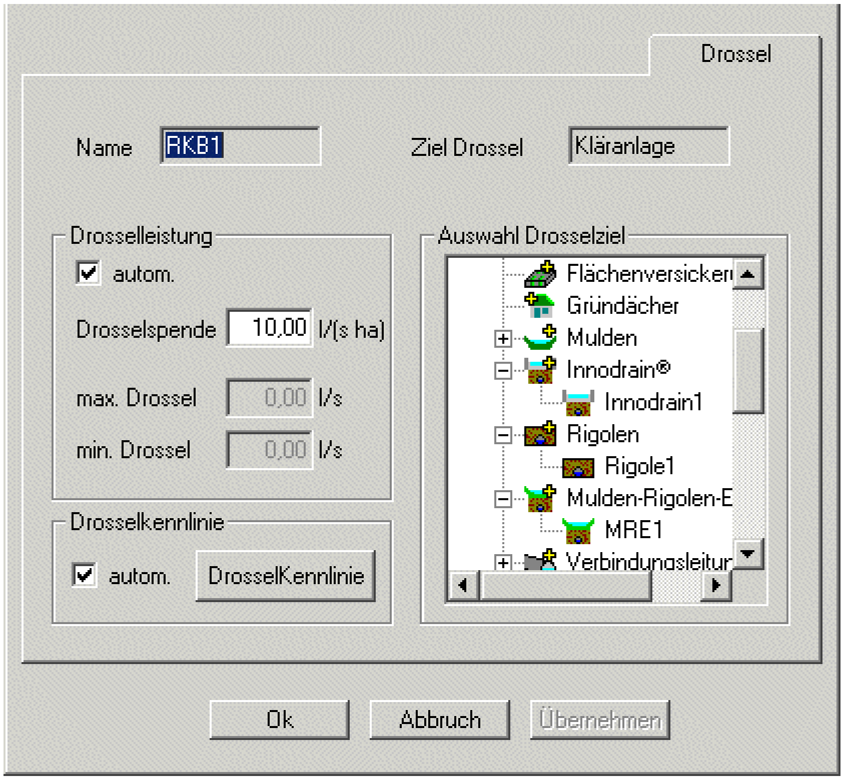
In the "Fit Dimensions" section you have the ability to adjust the element's volume to the required volume. The required volume is known from dimensioning.

Choose whether you want to adjust length, width or depth. In the "existing value" field, the current value is shown. In the "required value" field, the newly calculated value is shown. This is the value required to provide enough storage volume. If the existing value is not enough, the output is shown in red, otherwise in green.

By clicking on the "Fit" button, the adjustment is made; i.e. the current value is saved.

System Elements Properties: Throttle Tab

Soil Filters, Innodrain, Swale-Trench Elements, Trenches, Stormwater Sedimentation Tanks, Stormwater Retention Tanks



In the properties dialog for the system elements "*Soil filters*", "*Innodrain*", "*Swale-Trench Elements*", "*Trenches*", "*Stormwater Sedimentation Tanks*" and "*Stormwater Retention Tanks*" you'll find the "Throttle" tab.

Throttle Performance In the "Throttle Performance" section you can pre-set an catchment-specific throttle intensity. The default value is 10 l/(s*ha). At the same time, the discharge is automatically calculated as a function of the connected runoff-effective surface.

If the "autom." checkbox is deactivated, you can manually define an element-specific throttled discharge capacity in the "max. throttle" field. The max. throttle capacity is reached when the element is full. In the programme, the throttle characteristic curve is determined from this, in case it is not entered manually.

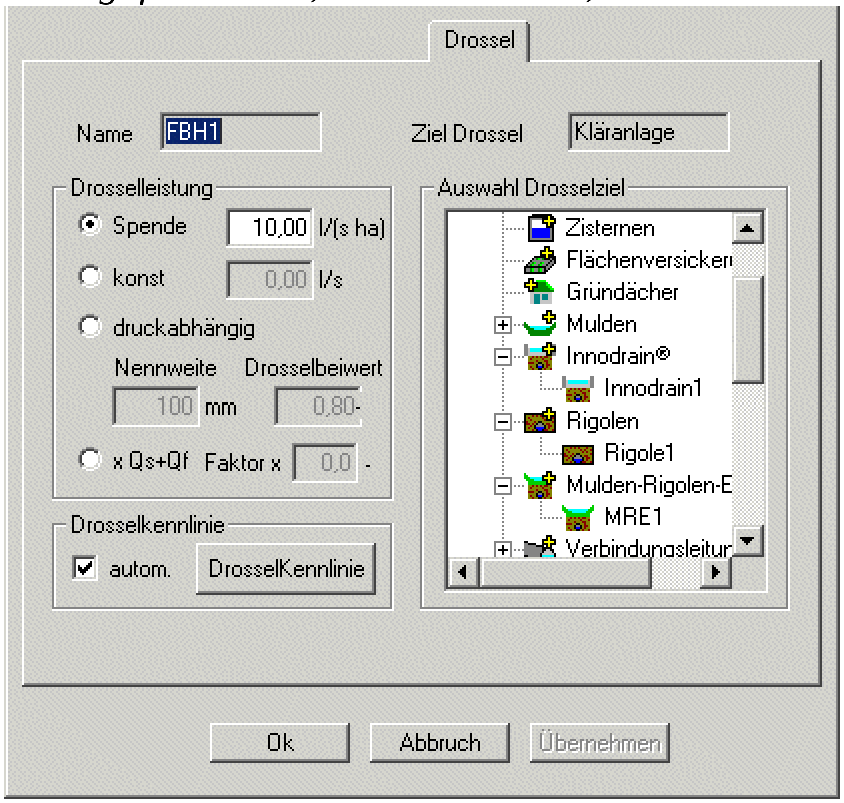
Throttle Characteristics In the "Throttle Characteristics" section, the element's throttle characteristic curve is defined. The throttle curve depicts the throttle capacity (in l/s) as a function of water level h (in m).

If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise, you can set the curve manually.

Choose Throttle Destination In the "Choose Throttle Destination" section you can select any element as the destination for the throttled discharge.

System Elements Properties: Throttle Tab

Throughflow Tanks, Retention Tanks, Sewers with Storage Capacity



In the properties dialog for the system elements "*Throughflow Tanks*", "*Retention Tanks*", and "*Sewers with Storage Capacity*" you'll find the "*Throttle*" tab.

Throttle Performance In the "Throttle Performance" section you can pre-set a catchment-specific throttle intensity. The default value is 10 l/(s*ha). At the same time, there is an automatic calculation of the discharge as a function of the connected runoff-effective surface.

If the "autom." checkbox is deactivated, you can manually define an element-specific throttle discharge capacity in the "max. throttle" and "min. throttle" fields. The min. throttle capacity applies to the empty tank. The max. throttle capacity is reached when the element is full. In the programme, the throttle characteristic curve is calculated from this in case it was not entered manually.

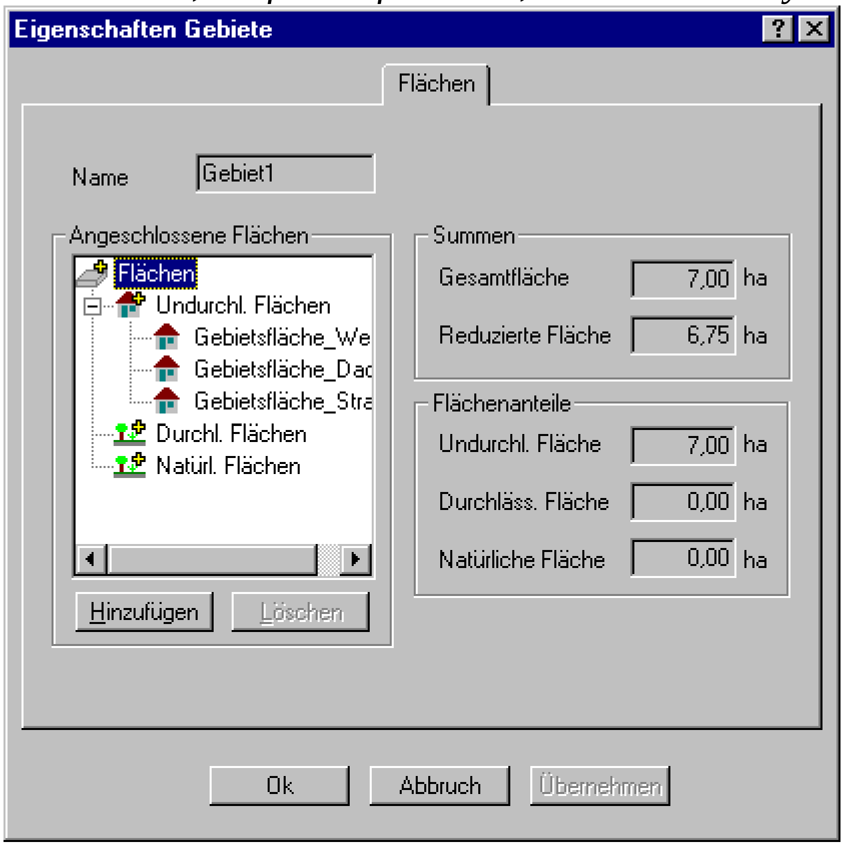
Throttle Characteristics In the "Throttle Characteristics" section, the throttle characteristic curve is defined for the element. The throttle curve depicts the throttle capacity (in l/s) as a function of water level h (in m).

If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise the curve can be set manually.

Choose Throttle Destination In the "Choose Throttle Destination" section you can choose any element as the destination for the throttled discharge.

System Elements Properties: Surfaces Tab

Catchments, Surface Infiltration, Natural Watercycle Objects



In the properties dialog for system elements Catchments, Surface Infiltration, and the natural watercycle obejcts you'll find the "Surfaces" tab. This dialog field is active, it serves to show connected surfaces.
New surfaces can be added using the "Add" button or deleted using the "Delete" button. If you add a new surface here, you'll be asked whether you really want to separate it from its original drainage destination.

Summation

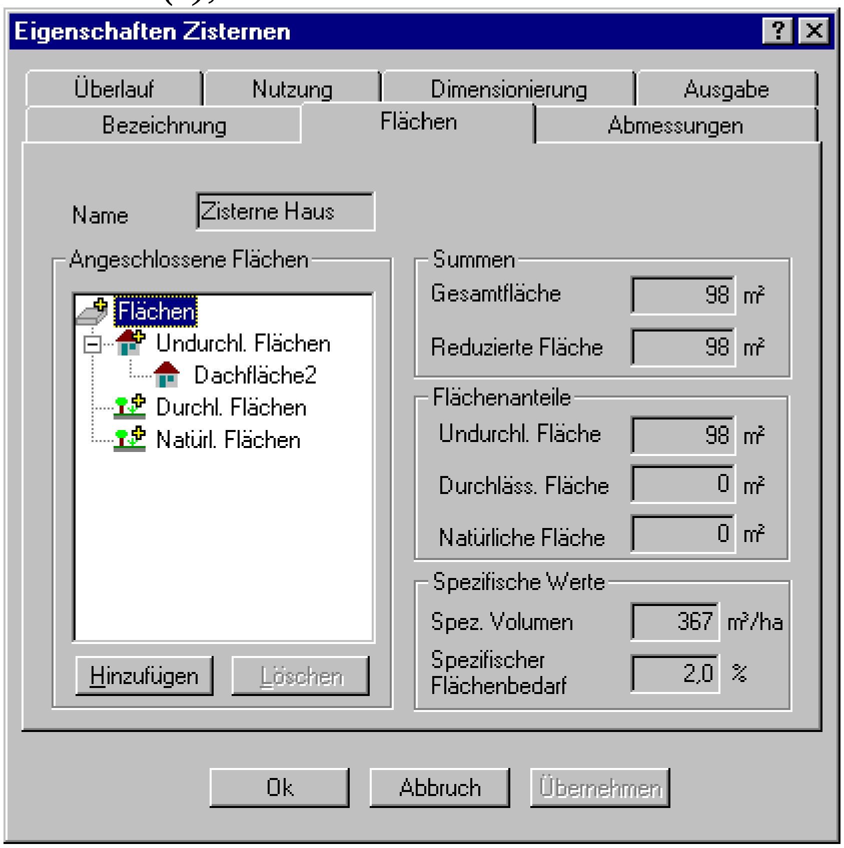
In the "Summation" section, the total surfaces as well as the reduced surfaces are shown in mē.

Surface Share

In the "Surface Share" section, the surfaces appear subdivided into implermeable, permeable, and natural surfaces.

System Elements Properties: Surfaces

Surfaces, Cisterns, Green Roofs, Swales, Trenches, Swale-Trench Elements, Innodrain(c), Stormwater Retention Tanks



In the properties dialog for the system elements listed above you'll find the "Surfaces" tab. This is an active dialog field; it serves to show connected surfaces.
New surfaces can be added here using the "Add" button or deleted using the "Delete" button. Whenever you add a surface here, you'll be asked whether you really want to separate it from the original drainage destination.

Summation
In the "Summation" section, the total surface appears as well as reduced surface is shown in m^2.

Surface Share
In the "Surface Share" section, surfaces appear subdivided into impermeable, permeable and natural surfaces.

Specific Values

In the "Specific Values" section, calculated specifications are shown.

The value in the "Spec. Volume" field shows the specific storage volume based on conncected surface in m³/haAred.

The specific surface requirements shows the ratio of required surface for drainage elements to connected runoff-effective surface.

System Elements Properties: Overflow Tab

Cisterns, Green Roofs, Swales, Trenches, Innodrain(c), Stormwater Retention Tanks

In the properties dialog for the system elements above you'll find the "Overflow" tab.

Input

Overflow Hight
In the "Input" section you can enter the hight of the overflow based on the element's impound bottom in the "Overflow Hight" field. The hight generally corresponds to the element's depth. With Swale-Trench elements, it is absolutely sensible to locate the overflow underneath the max. depth.
Max. StorageVol.
In the "Max. StorageVol." field the volume that the system element can accommodate when the overflow hight is reached is shown. This is automatically calculated.

Overflow Performance

In the "Overflow Performance" section, the max. overflow performance is given. If the "autom." checkbox is activated, the overflow performance is calculated automatically.

Overflow Characteristics
In the "Overflow Characteristics" section, the element's overflow characteristic curve is defined. The overflow curve depicts the element's overflow performance (in l/s) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise the characteristic curve can be adjusted manually.

Retention Tanks Properties: Overflow Tab

Online or By-pass

In the properties dialog for the retention tanks you'll find the "Overflow" tab.

Input

Overflow Hight
In the "Input" section you can enter the hight of the overflow based on the element's impound bottom in the "input" field. The hight generally corresponds to the element's depth.

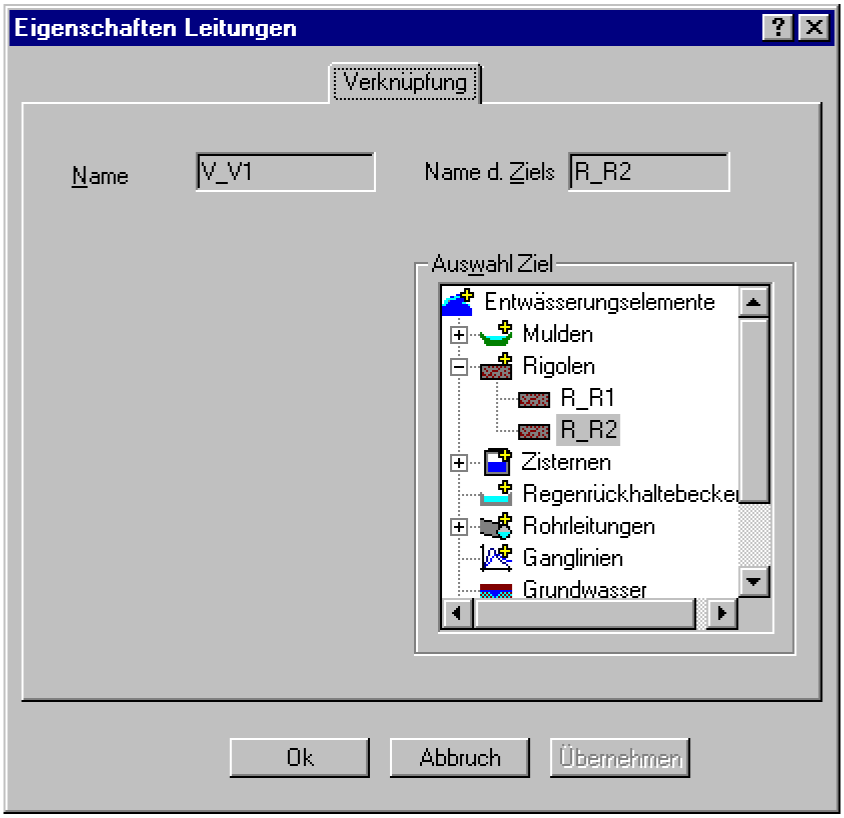
Overflow Performance

In the "Overflow Performance" section, the threshold length and overflow coefficient are given. If the "autom." checkbox is activated, the overflow performance is calculated automatically.

Overflow Characteristics
In the "Overflow Characteristics" section, the element's overflow characteristcis curve is defined. The overflow curve depicts the element's overflow capacity (in l/s) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise the curve can be adjusted manually.

System Elements Properties: Link Tab

Catchments, Sewage Channels, Groundwater, Rivers/Streams, Outlets

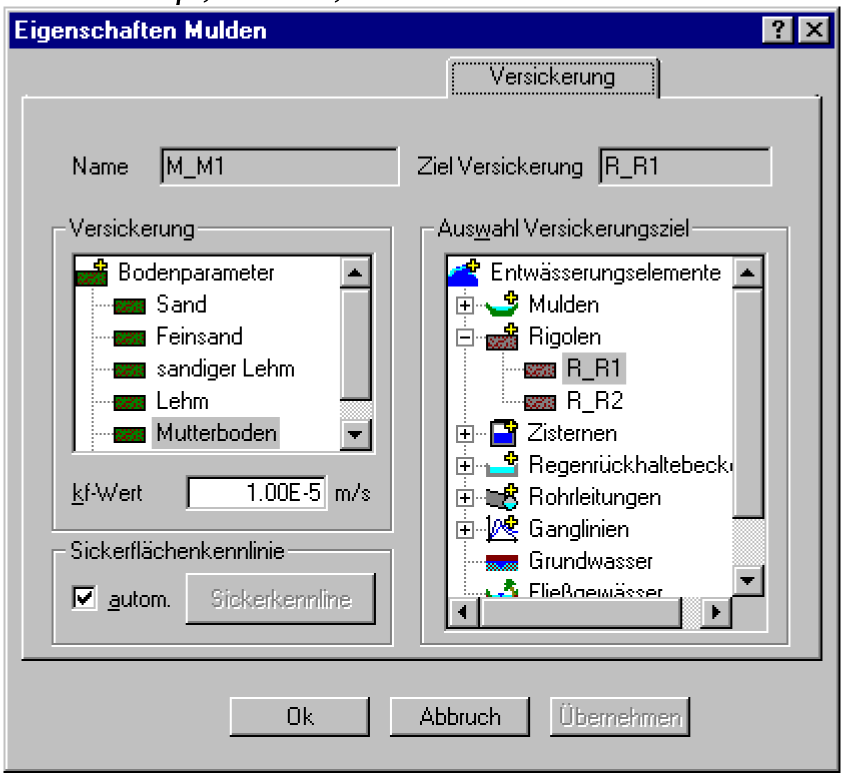


In the properties dialog for the system elements listed above you'll find the "Link" tab.

In the "Choose Destination" section you can select any element as the destination for the discharge.

System Elements Properties: Infiltration Tab

Green Roofs, Swales, Trenches



In the properties dialog for the system elements "Swales," "Trenches" and "Green Roofs" you'll find the "Infiltration" tab.

Infiltration
In the "Infiltration" section you can indicate the type of soil for infiltration. For the swale this is usually topsoil (swale bed under the swale). For the trench, it depends on the soil located under the trench.
The **Kf-value** is applied according to the selected soil type or can be entered manually (in m/s, scientific notation is possible).

Infiltration Surface Characteristics

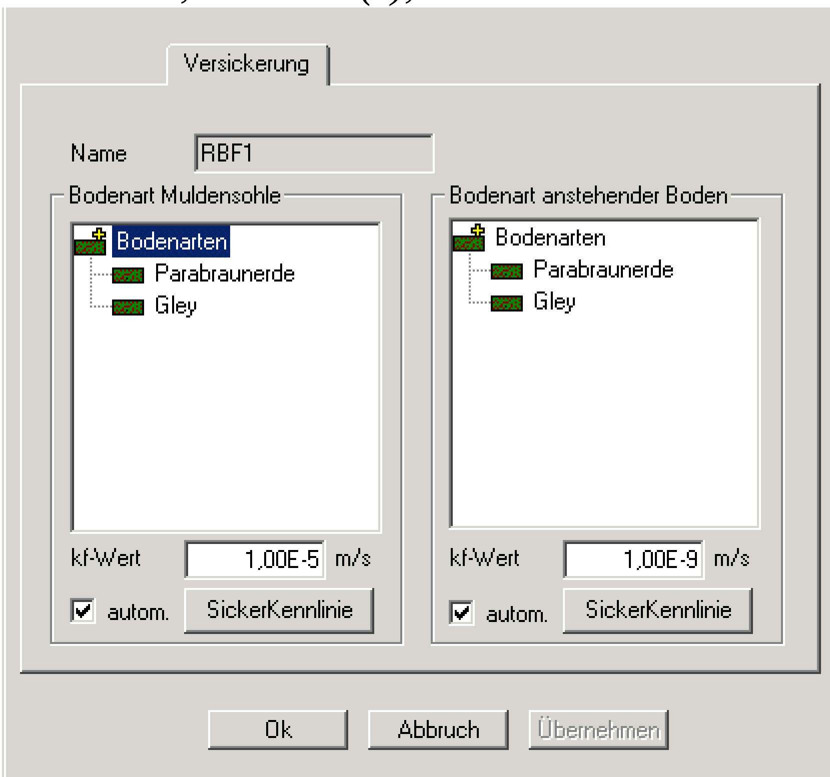
In the "Infiltration Surface Characteristics" section, the infiltration characteristic curve for the swale or trench is defined. The infiltration curve depicts the infiltration surface area (in mē) as a function of water level h (in m).

If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise the curve can be adjusted manually.

Choose Infiltration Destination
In the "Choose Infiltration Dest." section you can select the element into which the infiltrated water should flow.

System Elements Properties: Infiltration Tab

Soil Filters, Innodrain(c), Swale-Trench Elements



In the properties dialog for the system elements "Swale-Trench Elements" and "Innodrain(c)" you'll find the "Infiltration" tab. Here you can indicate the type of soil for the infiltration from the swale (swale bottom) and the trench (trench bottom).

Swale Bottom Soil Type, Soil Type of Surrounding Soil

In the sections labled "Swale Bottom Soil Type" and "Soil Type of Surrounding Soil" you can indicate the type of the soil for infiltration. For the swale, this is generally topsoil (swale bed under the swale). For the trench, this entry depends on the soil located under the trench.

The **Kf-value** is applied according to the selected soil type or can manually entered manually (in m/s, scientific notation possible).

1.3.1 Allgemeine Angaben

Nach dem Anlegen einer neuen Datei bzw. nach dem Importieren einer Datei einer früheren Programmversion sollten zunächst allgemeine Angaben zur eigenen Firma, zum Projekt sowie zu Simulations- und Bodenparametern gemacht werden. Die eingegebenen Firmen- und Projektdaten erscheinen auf der zweiten Seite im Ergebnisbericht unter „Allgemeines“ als Unterpunkte „Auftragnehmer“ und „Projekt“.

1.3.1.1 Company Data

Data regarding the company are given in the dialog window "Company Data Properties," which is opened from the main menu or by double clicking on "Company data" in the element tree.

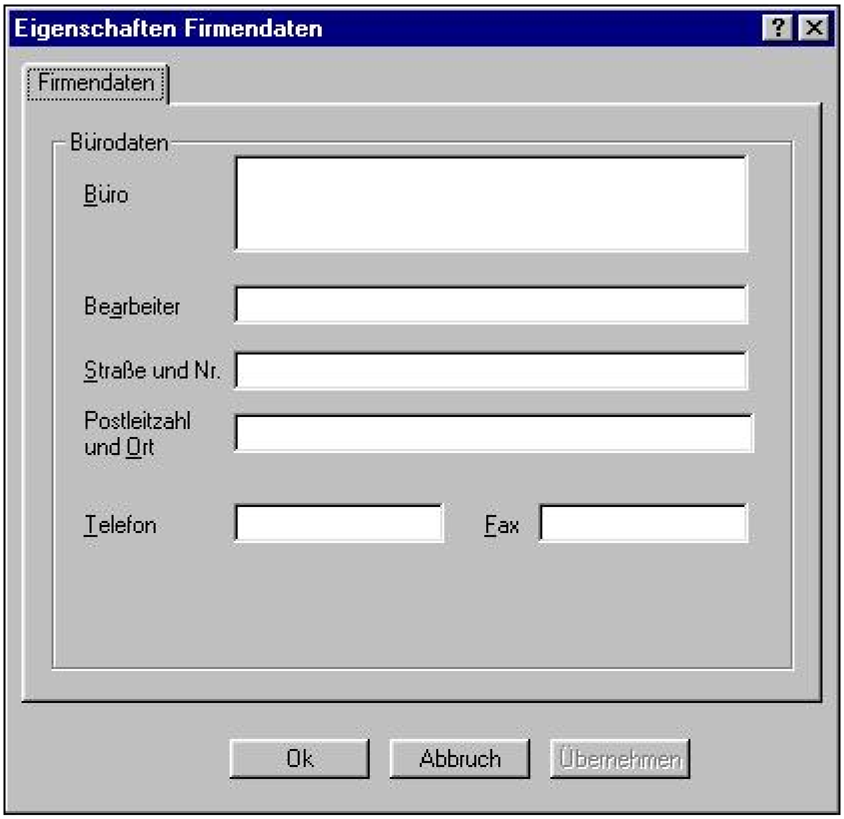


Figure 3-1: Dialog window for entering company data Input for the dialog fields is self-explanatory. It is not necessary to have entries in this dialog window in order for simulations for the trough-infiltration-trench (TRINT) system to be executed. Terminate the entry of company data by clicking on the "Apply" button.

1.3.1.2 Project Data

With a single click on "Project data" in the element tree you can directly switch to the next dialog window "Project Data Properties".

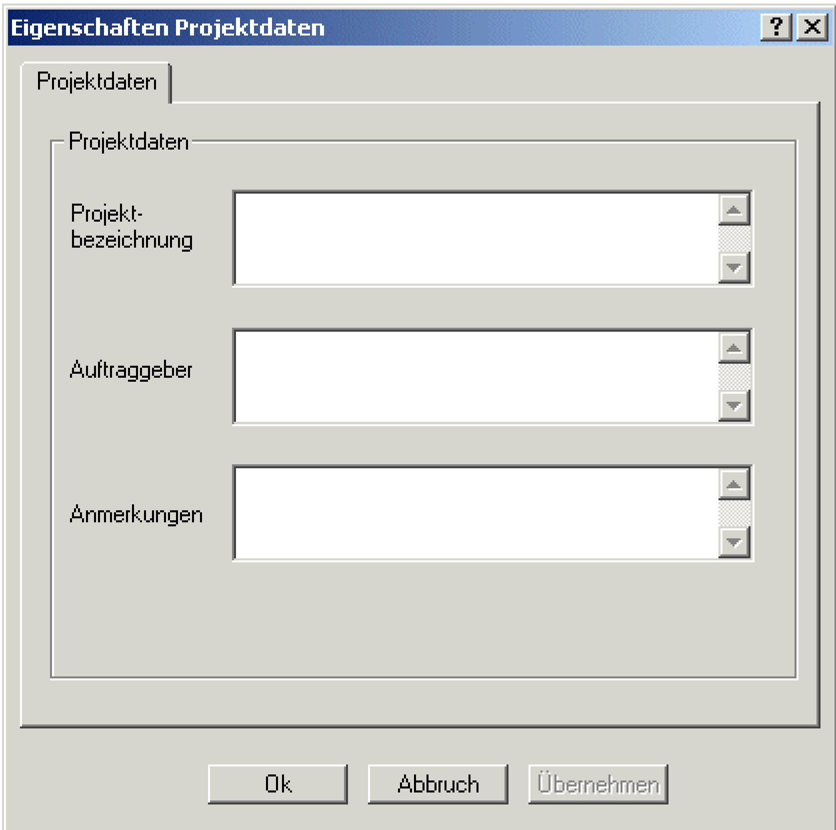
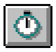


Figure 3-2: Dialog window for entering project data The entries "Project description" and "Contract awarded by" in this dialog appear on the title page of the output report. Multiple-line entries are not possible. Longer text is simply wrapped in the dialog window in order to be able to display it completely on the screen.

1.3.1.3 Simulation Parameters

 Clicking this button in the calculation toolbar opens the dialog window "Simulation Parameters Properties," in which specifications pertaining to the simulation period are entered.

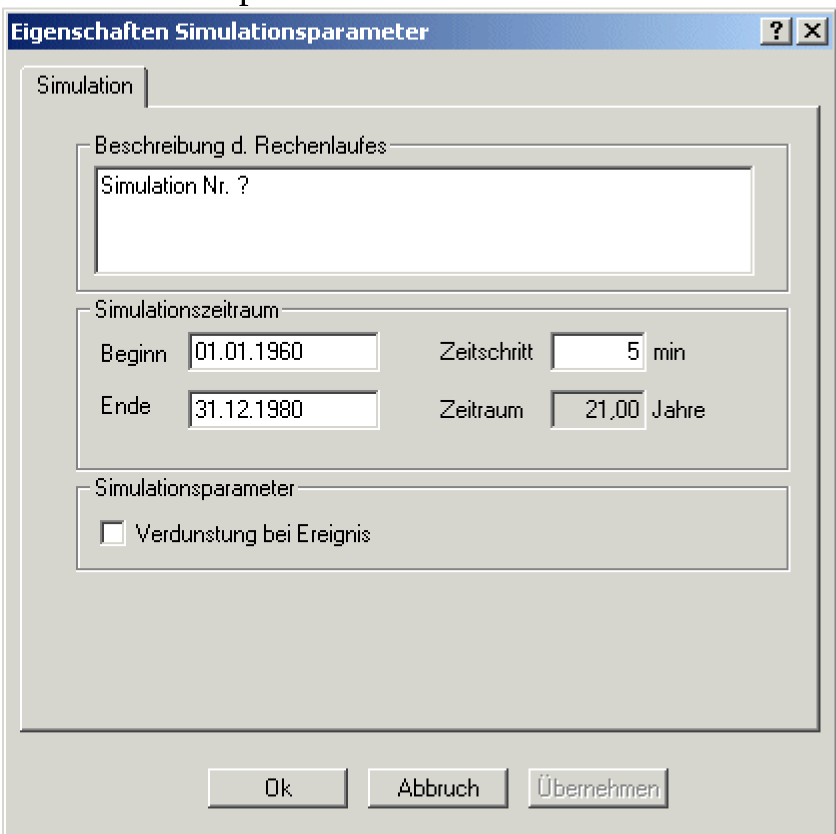


Figure 3-3: Dialog window for entering simulation parameters

The simulation time step should correspond to the time step in the rain data file. Assigning a name for the simulation is optional. The specifications to the simulation period, however, are mandatory.

1.3.1.4 Design Storms

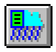
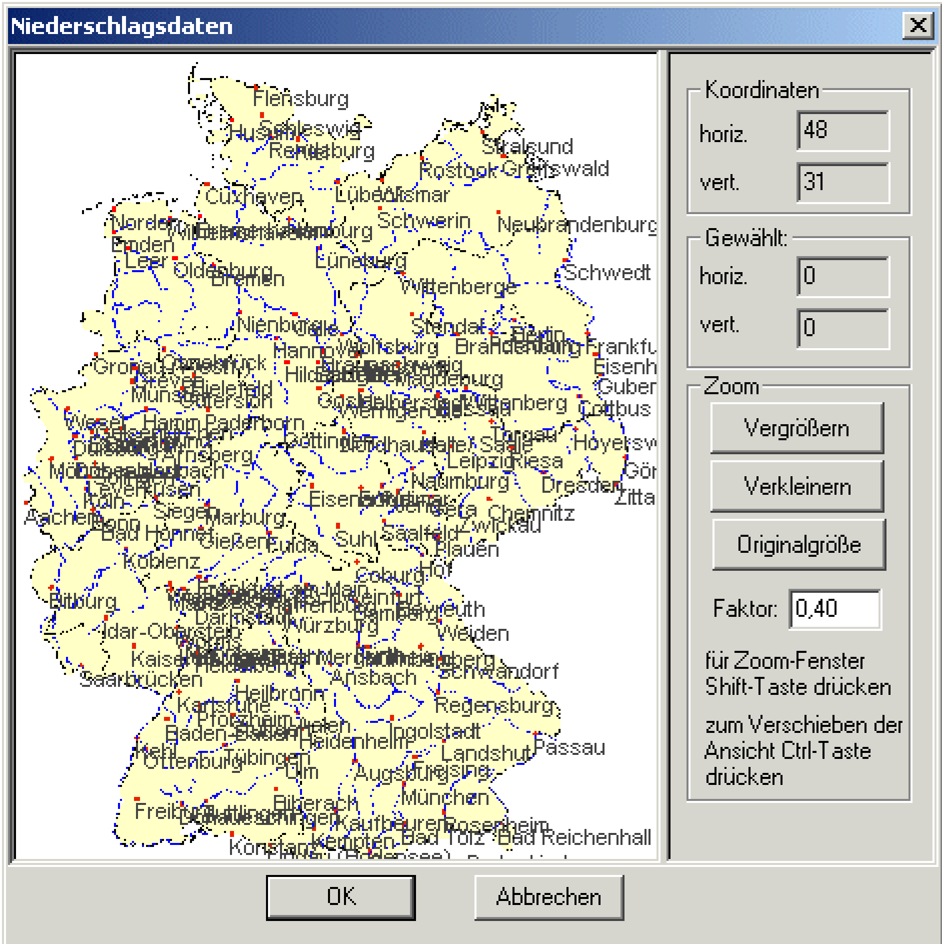
 Design storms can be edited by clicking on the button shown here or via the menu item "Design Storm..." in the "System Elements" pulldown menu.

Figure 3-12: Dialog window for inputting a design storm

In the Design Storm dialog window, there is initially the choice between two calculation methods (see Figure 3-12). You can choose either the method according to Reinhold or Heavy Rain Statistics according to Kostra. If you choose the method according to Reinhold, you can select the desired German city in the field titled "Rain intensity according to Reinhold." In the field next to it, the particular rain intensity of r15,1 in l/(s*ha) is automatically given.

With Heavy Rain Statistics according to Kostra, the field titled "Heavy Rain Table" becomes active. With the help of the button labled "Transfer from graphic", you can select the desired location in Germany.



The appropriate coordinates are automatically identified and applied to the calculations.
Using the buttons in the **Zoom** section, you can *enlarge* or *diminish* the graphic, or set it back to its *standard size*. You also also select an area to zoom in on by holding down the SHIFT-key and selecting an area of the graphic with the mouse, or you can scroll the map by holding down the CTRL-key and dragging the map with the mouse.

1.3.2 Stoffparameter

Durch Doppelklick auf „Stoffparameter“ im Objektbaum öffnen sich die vier Arten der Stoffparameter, die bearbeitet werden können.

1.3.2.1 Substance Parameters

By double-clicking on "Substance Parameters" in the element tree, you can view the four types of substance parameters, which can be edited.
After double-clicking on the sub-item "Substance parameters" the dialog window "Substance values properties" opens.

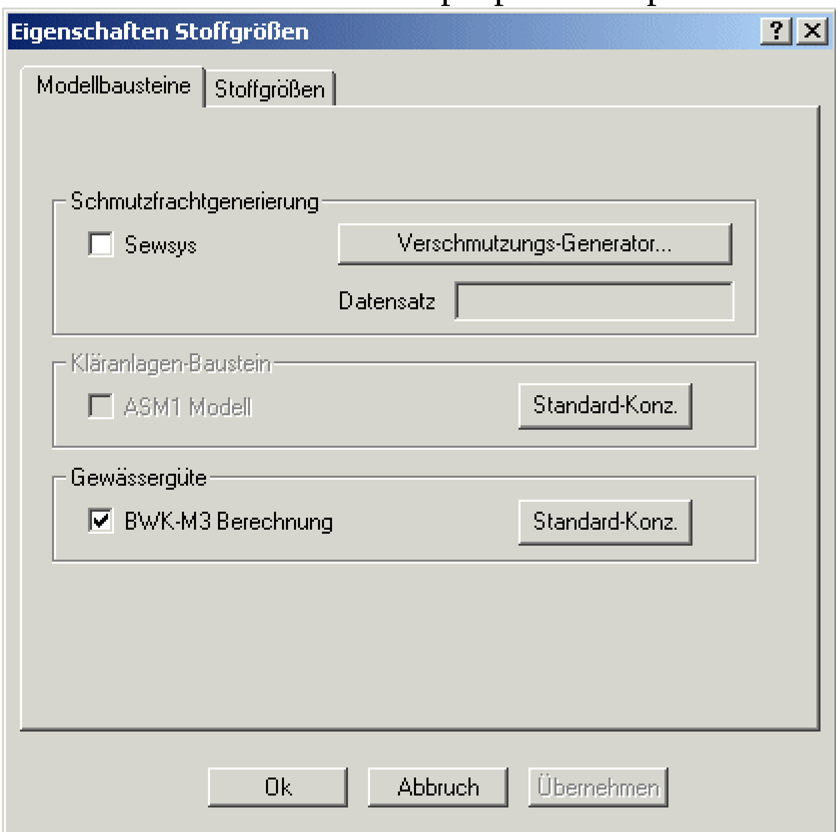
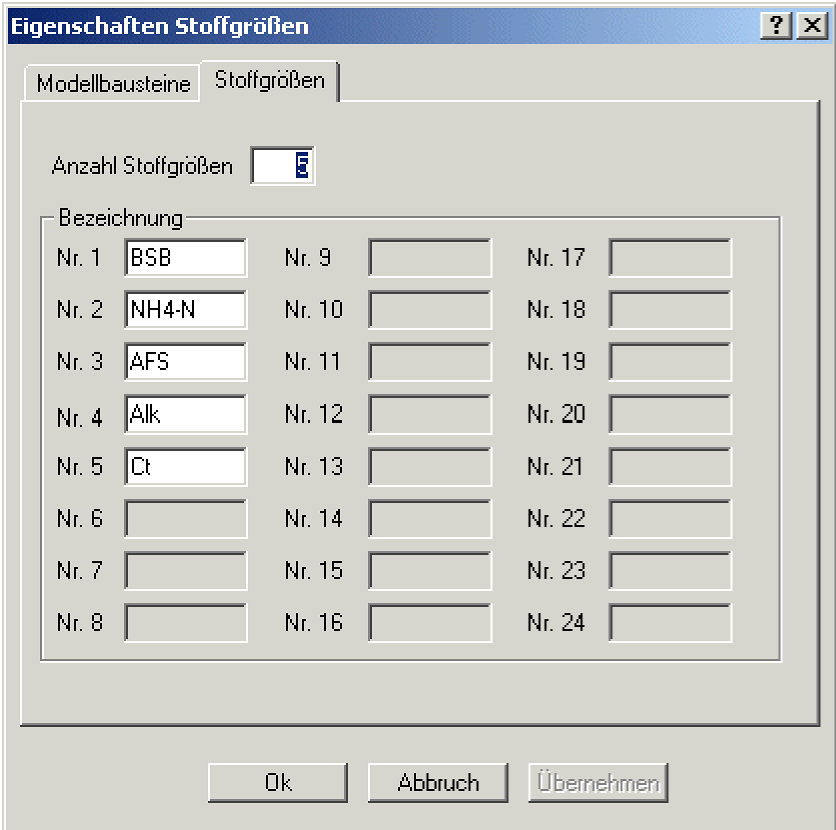


Figure 3-4: Dialog for entering substance values

First, the number of substance values (parameters) is set. In the "Designation" field, the names of the parameters are defined for as many parameters that exist. Up to 10 parameters can be entered and used for calculations in the simulation.
The input values for the single substance values are then set in the single elements for dry weather and rainwater runoff.


Eigenschaften Stoffgrößen
Modellbausteine
Stoffgrößen
Anzahl Stoffgrößen
5
Bezeichnung
Nr. 1
BSB
Nr. 2
NH4-N
Nr. 3
AFS
Nr. 4
Alk
Nr. 5
Ct
Nr. 6
Nr. 7
Nr. 8
Nr. 9
Nr. 10
Nr. 11
Nr. 12
Nr. 13
Nr. 14
Nr. 15
Nr. 16
Nr. 17
Nr. 18
Nr. 19
Nr. 20
Nr. 21
Nr. 22
Nr. 23
Nr. 24
Ok
Abbruch
Übernehmen

1.3.2.1.1 Stoffparameter: Stoffgrössen

Im Eigenschaftendialog der Stoffparameter finden Sie die Registerkarte "Stoffgrößen".

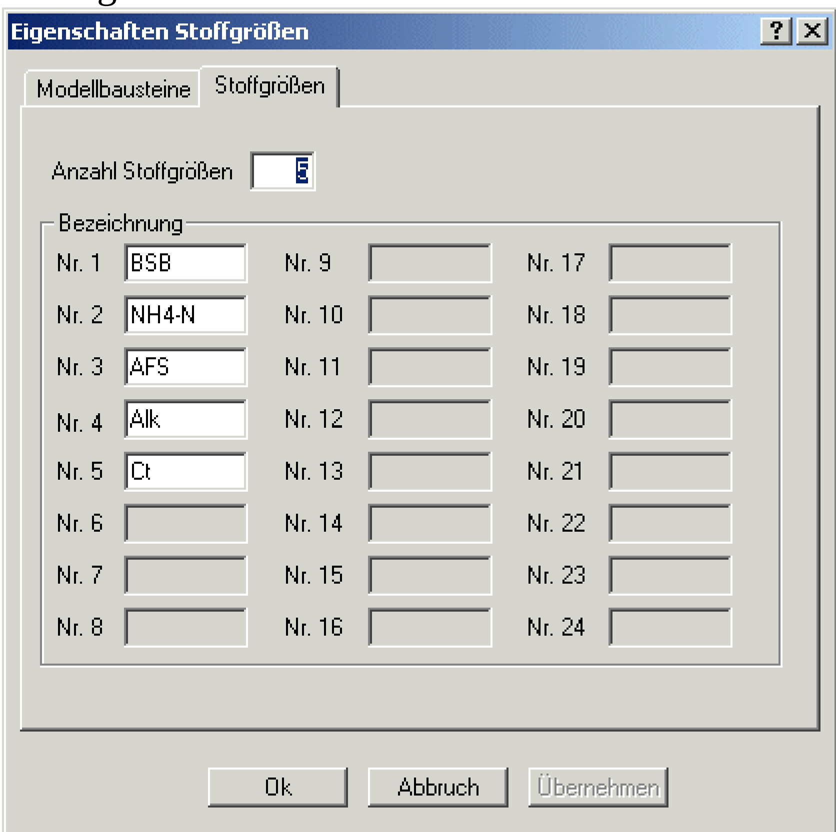


Abbildung 1-36: Eigenschaftsdialogfeld zur Erfassung der Stoffgrößen

Als erstes wird die Anzahl der Stoffgrößen (Parameter) festgelegt. Es können bis zu 24 Parameter eingetragen und mitgerechnet werden.In den Feldern „Bezeichnung“ werden entsprechend der eingangs festgelegten Anzahl der Stoffgrößen die Namen der Parameter definiert.

Die Eingangswerte für die einzelnen Stoffgrößen werden dann in den einzelnen Objekten für Trockenwetter und Regenabfluss festgelegt..

1.3.2.1.2 Stoffparameter: Sewsys-Konst

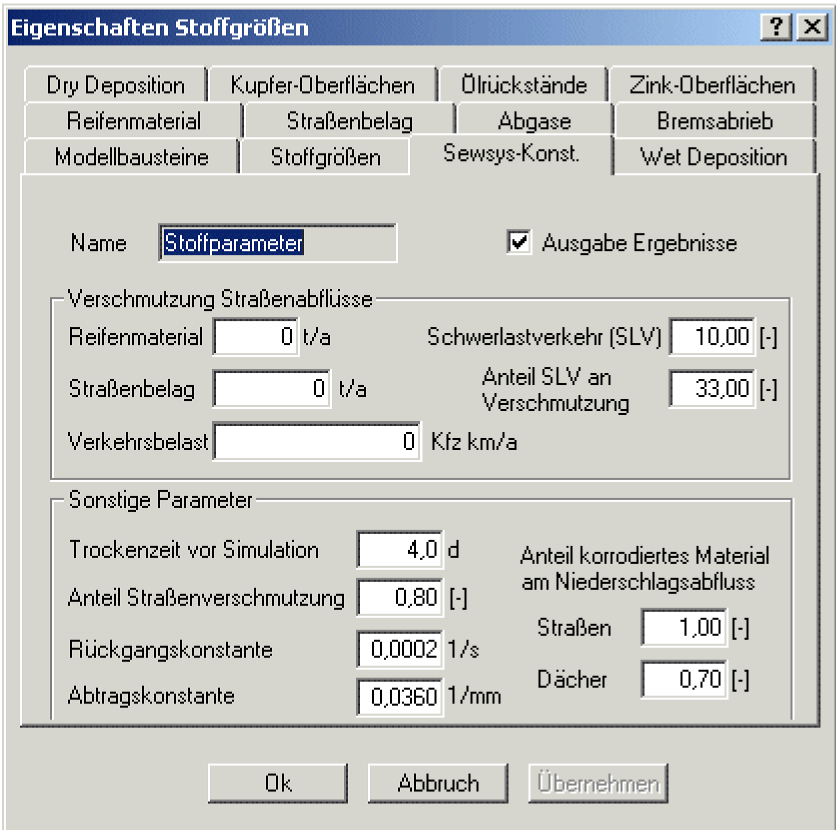


Abbildung 1-37: Eigenschaftsdialogfeld zur Erfassung der Sewsys-Parameter

1.3.2.1.3 Stoffparameter: Sewsys-Verschmutzung

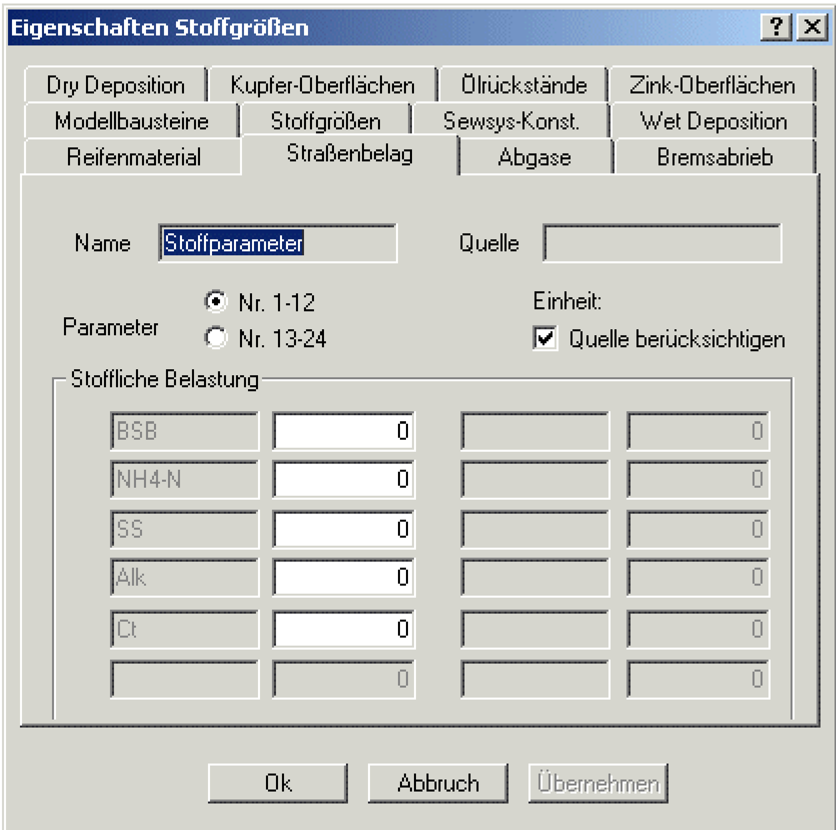


Abbildung 1-38: Eigenschaftsdialogfelder zur Erfassung der Sewsys-Verschmutzung

1.3.2.2 Stoffparameter Temperatur

Im Eigenschaftendialog der meisten Stoffparametersätze finden Sie die Registerkarte "Temperatur"

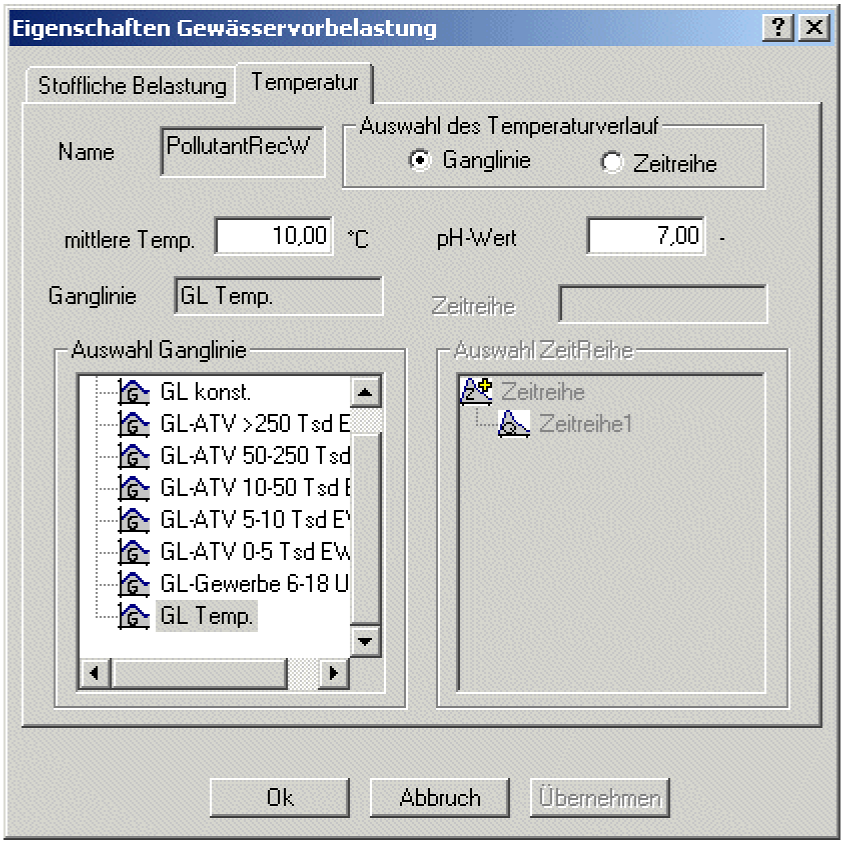


Abbildung 1-39: Eigenschaftsdialogfeld "Temperatur" für Ganglinien

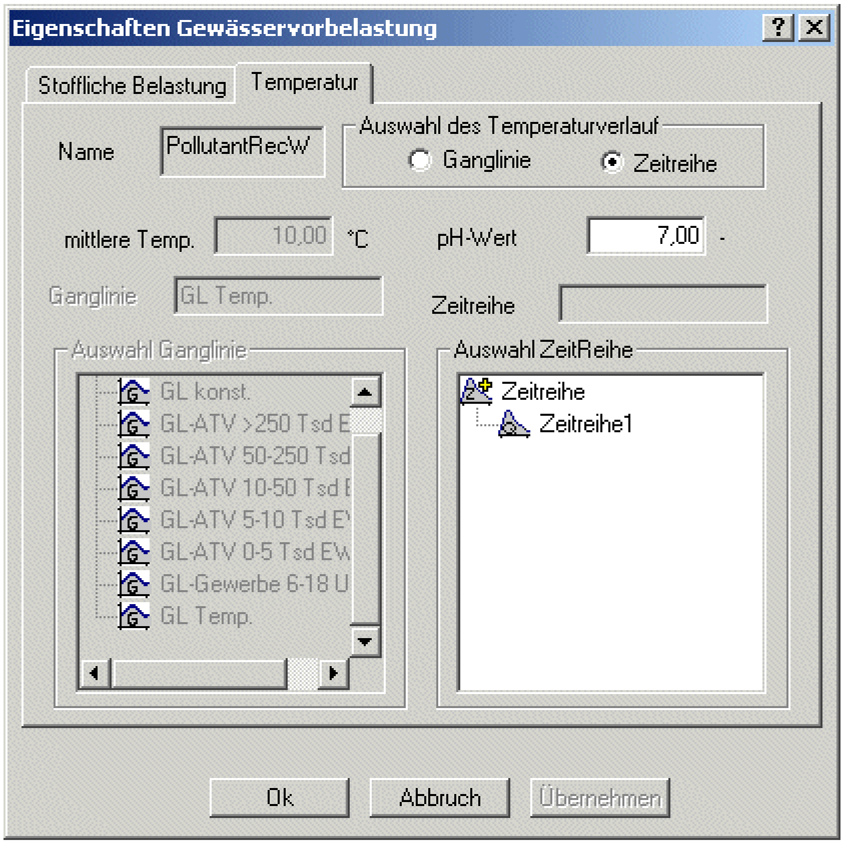


Abbildung 1-40: Eigenschaftsdialogfeld "Temperatur" für Zeitreihen

1.3.2.2 Substance Parameters, Rainwater

The "Rainwater Pollution Properties" dialog opens by double-clicking on the element "Substances (wet weather)" in the element tree.

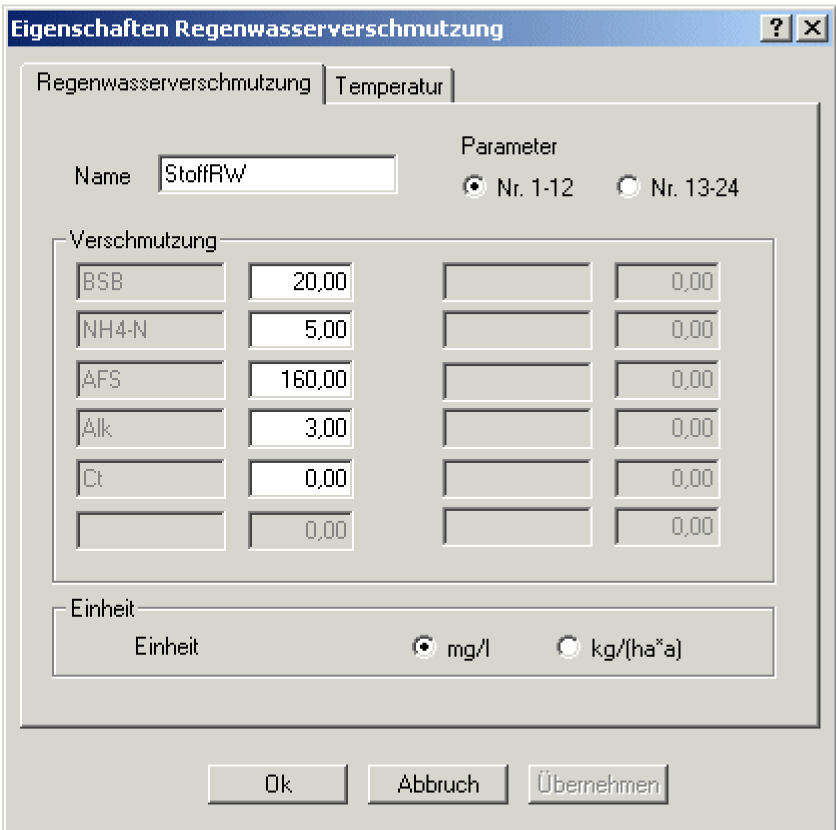
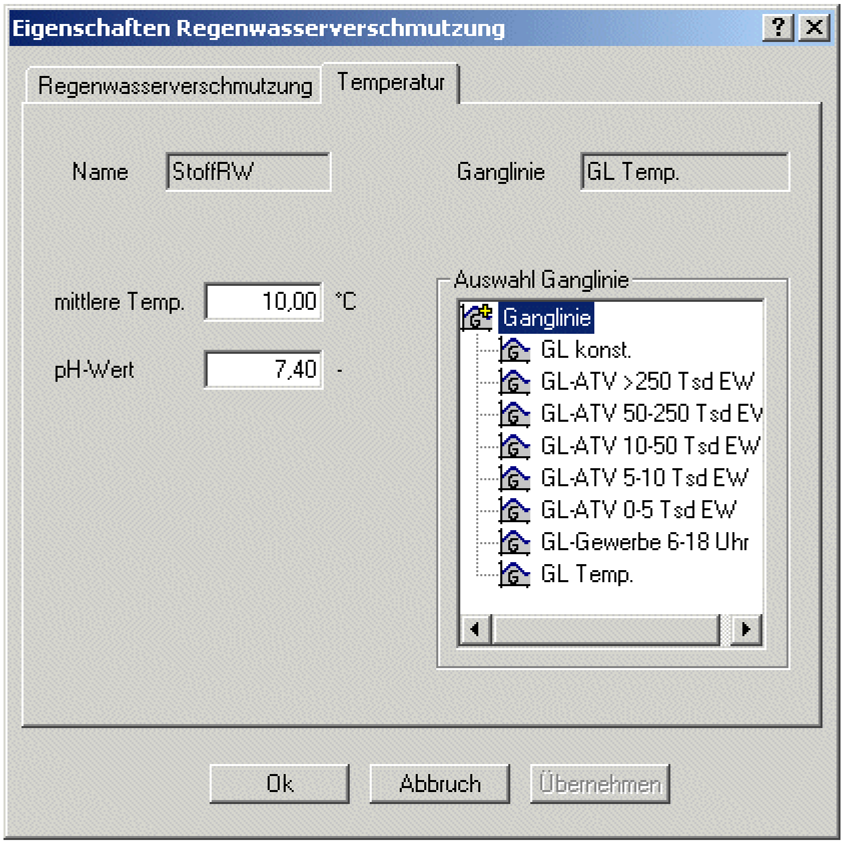


Figure 3-5: "Rainwater Pollution" dialog

Here you can assign rainwater pollution, either in mg/l or in kg/(ha*a), to the substance parameters created in section 3.2.1.


Eigenschaften Regenwasserverschmutzung
Regenwasserverschmutzung
Temperatur
Name
StoffRW
Ganglinie
GL Temp.
mittlere Temp.
10,00
°C
pH-Wert
7,40
-
Auswahl Ganglinie
Ganglinie
GL konst.
GL-ATV >250 Tsd EW
GL-ATV 50-250 Tsd EV
GL-ATV 10-50 Tsd EW
GL-ATV 5-10 Tsd EW
GL-ATV 0-5 Tsd EW
GL-Gewerbe 6-18 Uhr
GL Temp.
Ok
Abbruch
Übernehmen

1.3.2.3 Substance Parameters, Dry Weather

By double-clicking the element "Substances (dry weather)" in the element tree, you open the Dry Weather Pollution Properties.
Here you set the pollution for the substance parameters created in section 3.2.1.

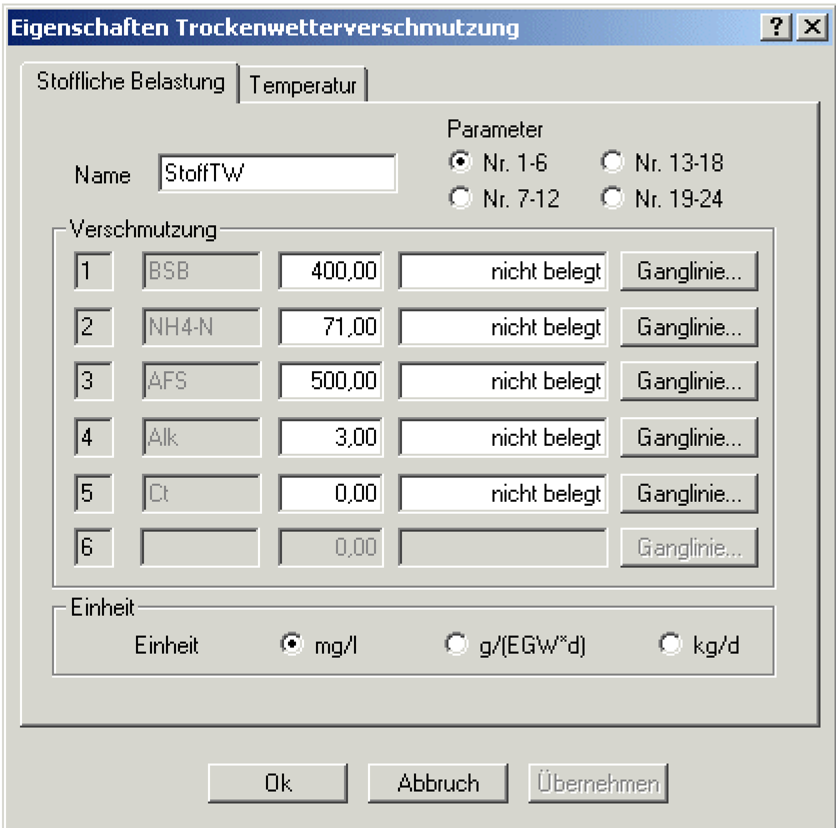
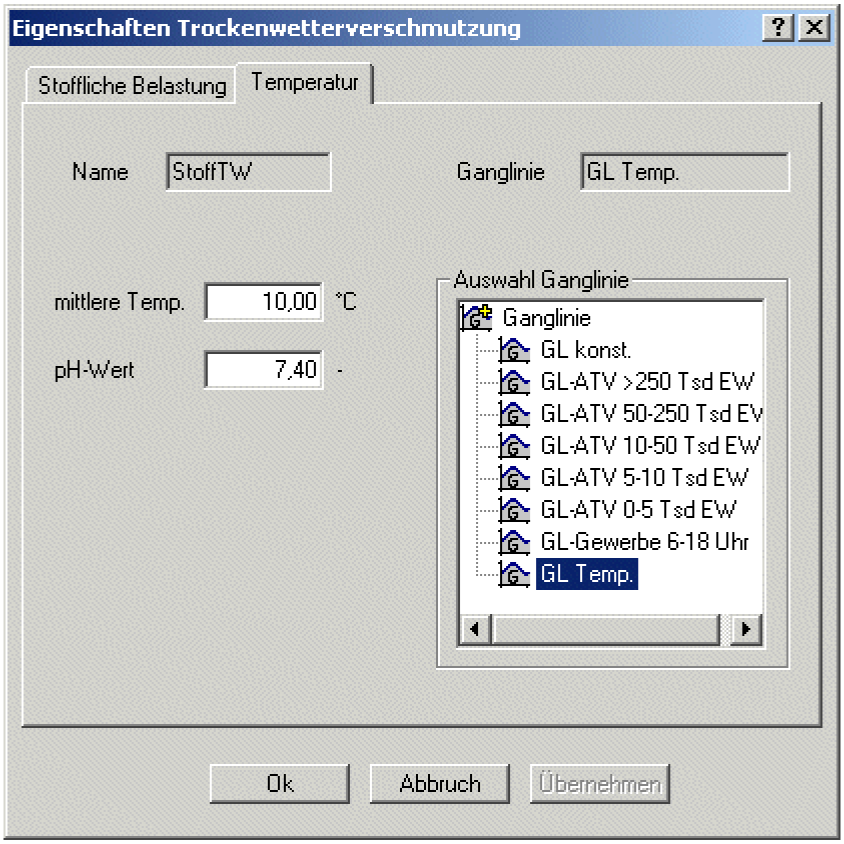
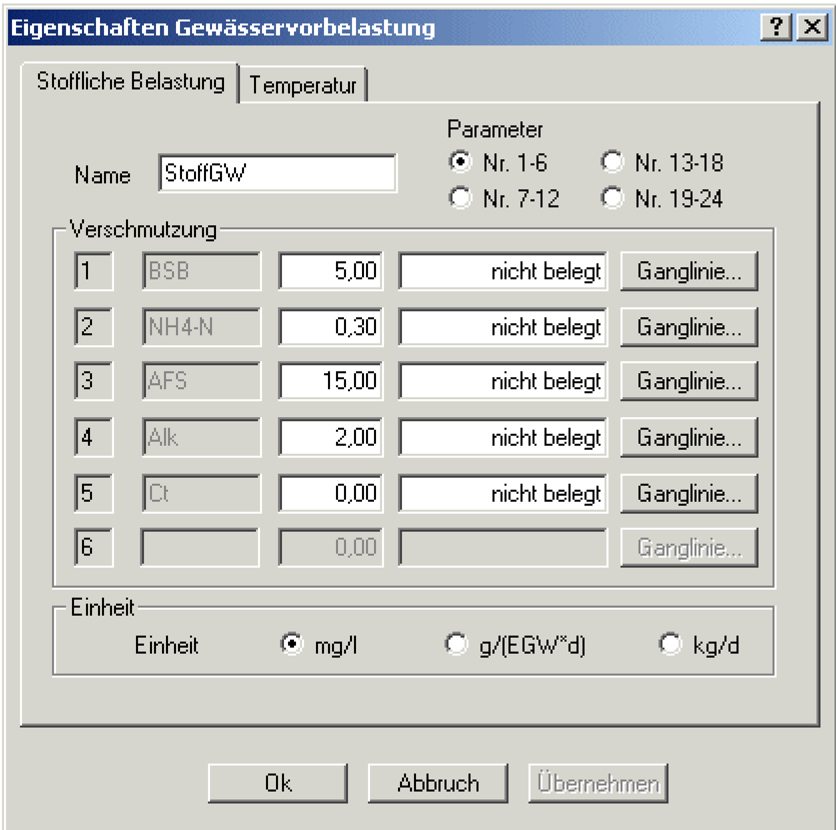


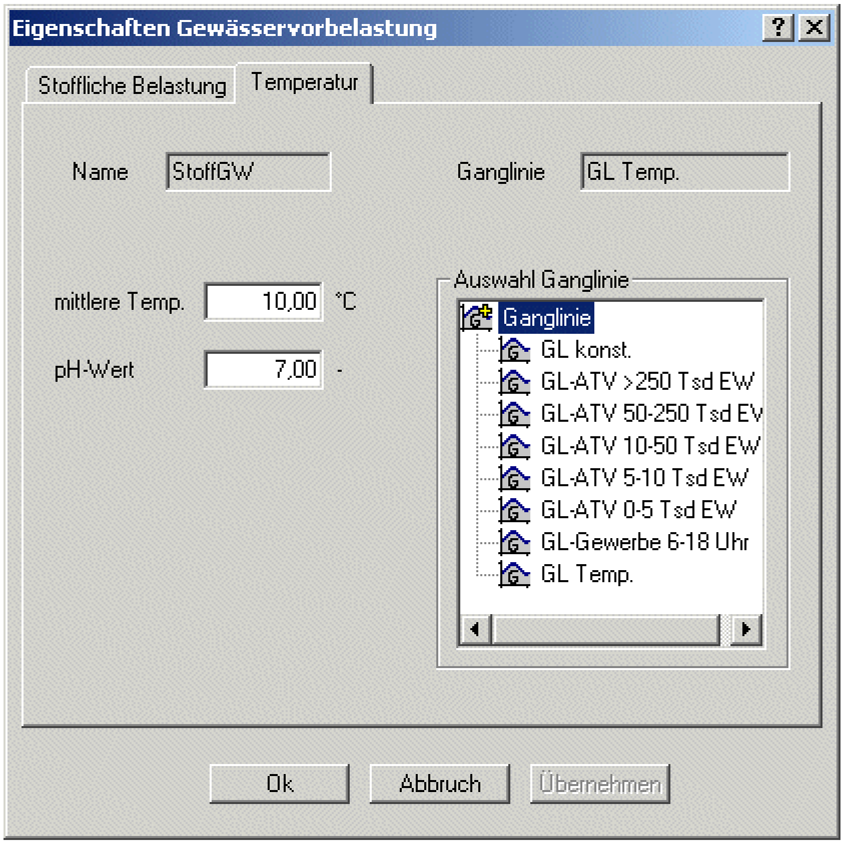
Figure 3-6: Dry Weather Properties Dialog

First, you define the names for this set of parameters. Here you can switch between the first 5 or last 5 parameters (because of limited space).
You now set the pollution values for the individually defined parameters.
You can assign each parameter a hydrograph by clicking on the "Hydrograph..." button.
You can select between the different units: mg/l, g/(PE*d) and kg/d.


Eigenschaften Trockenwetterverschmutzung
Stoffliche Belastung
Temperatur
Name
StoffTW
Ganglinie
GL Temp.
mittlere Temp.
10,00
°C
pH-Wert
7,40
-
Auswahl Ganglinie
Ganglinie
GL konst.
GL-ATV >250 Tsd EW
GL-ATV 50-250 Tsd EV
GL-ATV 10-50 Tsd EW
GL-ATV 5-10 Tsd EW
GL-ATV 0-5 Tsd EW
GL-Gewerbe 6-18 Uhr
GL Temp.
Ok
Abbruch
Übernehmen

1.3.2.4 Substance Parameters, Receiving Waters




Eigenschaften Gewässervorbelastung
Stoffliche Belastung
Temperatur
Name
StoffGW
Ganglinie
GL Temp.
mittlere Temp.
10,00
°C
pH-Wert
7,00
-
Auswahl Ganglinie
Ganglinie
GL konst.
GL-ATV >250 Tsd EW
GL-ATV 50-250 Tsd EV
GL-ATV 10-50 Tsd EW
GL-ATV 5-10 Tsd EW
GL-ATV 0-5 Tsd EW
GL-Gewerbe 6-18 Uhr
GL Temp.
Ok
Abbruch
Übernehmen

1.3.2.5 Substance Parameters, Sedimentation Behaviour

The final substance parameters, sedimentation behaviour, can be defined by double-clicking on the element "Sedimentation Behaviour" in the element tree.

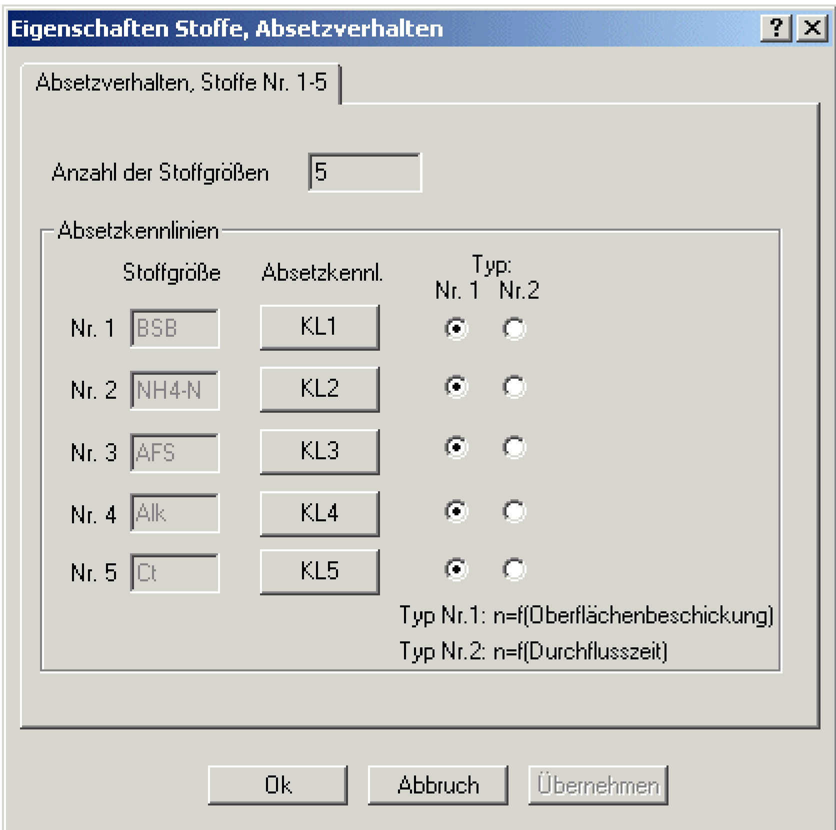


Figure 3-7: "Sedimentation Behaviour" Properties dialog

In the "Sedimentation Curve", the sedimentation behaviour can be selected for substance parameters. Each substance value is assigned a sedimentation curve. Furthermore, you can select between Type 1 and Type 2. Type No. 1 is calculated according to surface loading, whereas Type No. 2 is a function of flow.

1.3.3 Ganglinien

Durch den Doppelklick auf das Wort „Ganglinie“ im Objektbaum bietet sich dem Anwender die Möglichkeit des Zugriffs auf die vier verschiedenen Unterpunkte, Tages-Ganglinie, Wochen-Ganglinie, Jahres-Ganglinie und Ganglinie, an.
Eine Ganglinie gibt einen ersten Aufschluss über die zeitliche Reihenfolge von Daten und über die Art, Größe und den Zeitpunkt des Auftretens von Schwankungen.

1.3.3.1 Day Hydrographs

By double-clicking on "Day Hydrographs" you have the possibility to choose one of seven existing hydrographs. Here one differentiates by constant hydrographs, hydrographs from locations with various population figures, and industrial areas.
In the properties dialog for the system element "Day hydrographs" you set the name and the relative distribution factors for the hydrograph.
At the start, the name must be set. The "sum" field next to it indicates the sum of the 24 relative factors. This must amount to 24. The "Graphic..." button next to it shows an optical representation of the distribution.

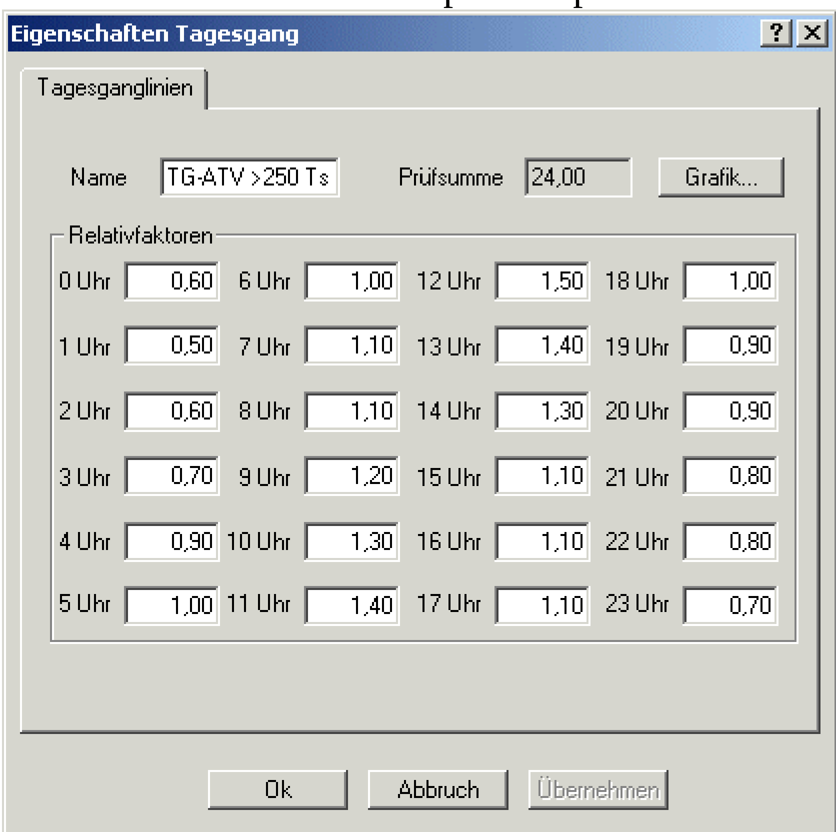


Figure 3-8: Day Hydrograph dialog window

The "Relative Factors" section, you define the runoff's factors for single hourly intervals in respect to the average daily runoff. These facors are overlaid with the factors for the week hydrographs and year hydrographs.

1.3.3.2 Week Hydrographs

By double-clicking on "Week Hydrographs" you can open the seven existing hydrographs. Here as well they are differentiated by constant hydrograph, hydrographs from locations with various population figures, and industrial areas.

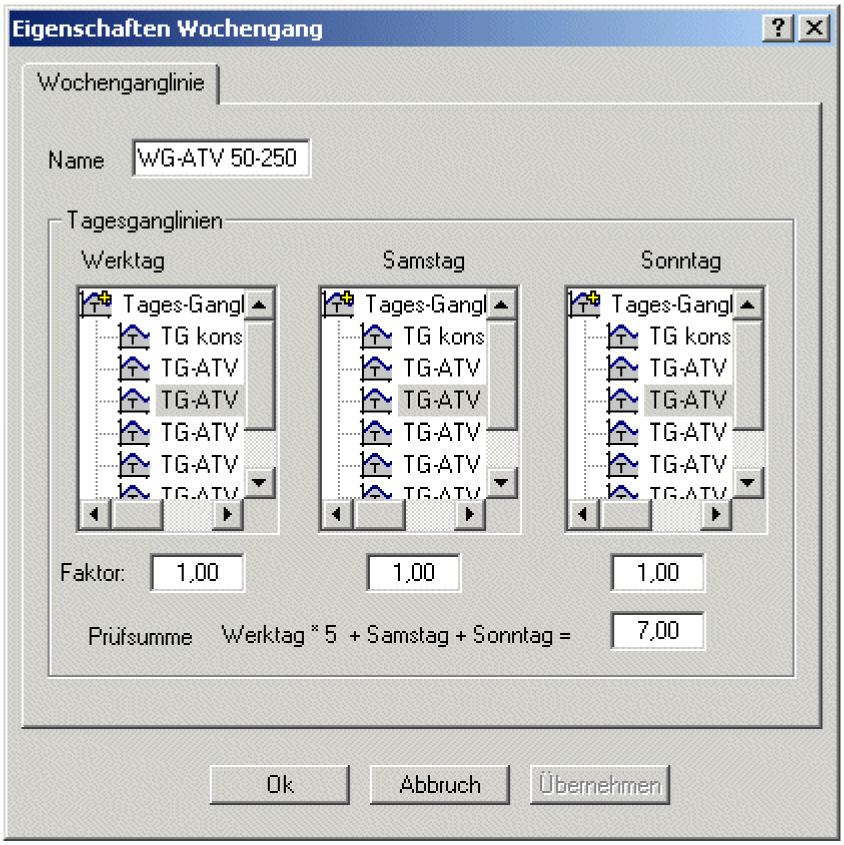


Figure 3-9: Entering a week hydrograph First you enter the name.

In the "Day hydrograph" section, you can define the appropriate hydrographs for weekdays, Saturday and Sunday. The days are allocated factors for weighting.

The "Sum" field below shows the sum of the 7 relative factors. It must amount to 7.

These factors are overlayed with the factors for the day hydrographs and year hydrographs.

1.3.3.3 Year Hydrographs

By double-clicking on "Year Hydrographs" in the element tree you open two sub-indexes, one called "YH const." and the other called "YH Temp". In the "YH konst." index, the relative factors are all assumed to be 1 so that there is a straight-line hydrograph.
In contrast, various relative factors for the 12 months can be entered in the "YH Temp." index.
In the "Year Hydrographs" properties dialog you set the name and the relative distribution factors for the hydrograph.

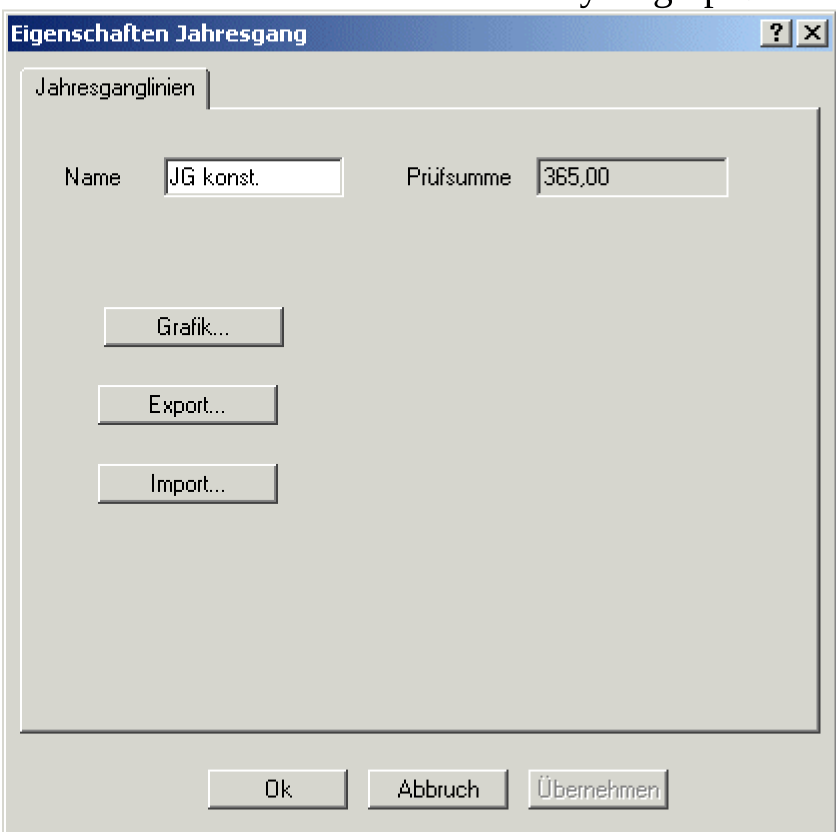
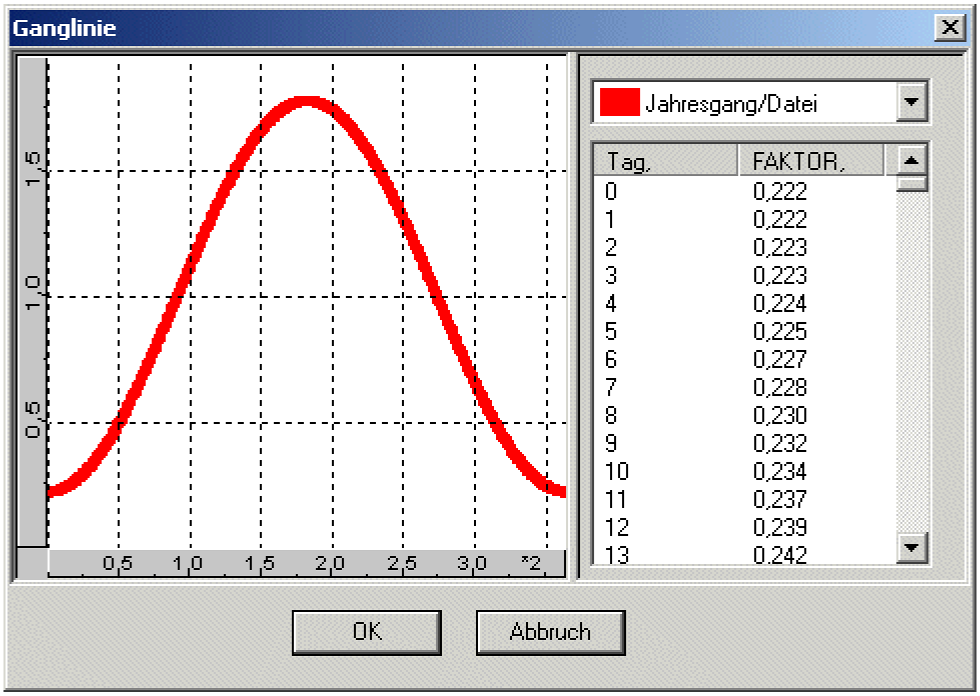


Figure 3-10: Year hydrograph properties dialog

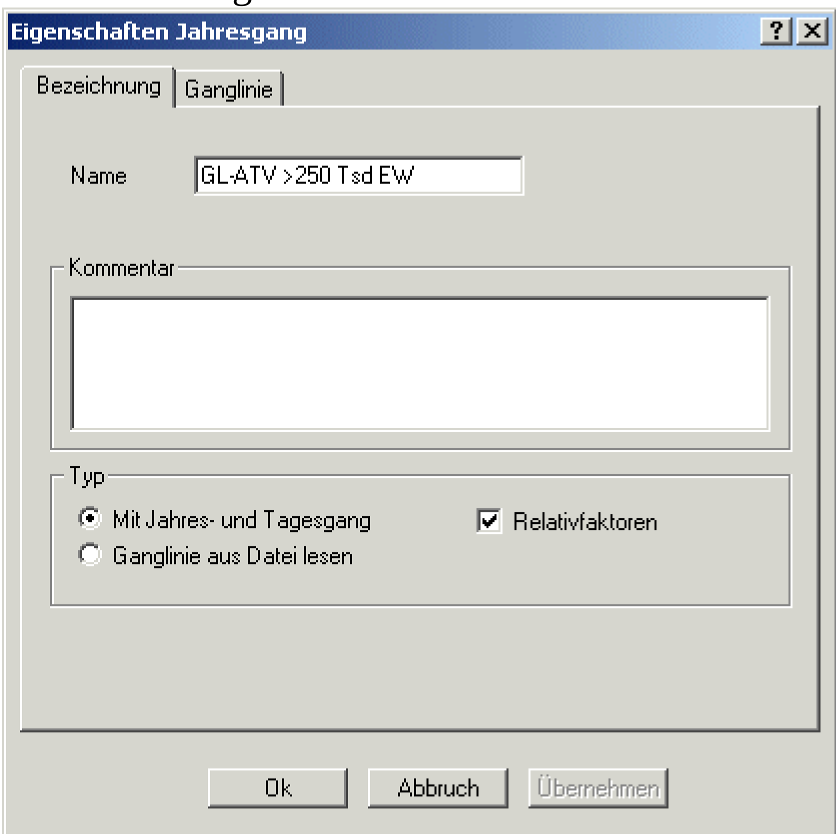
First the name must be entered.
The "Sum" field next to it shows the sum of the 12 relative factors. This must amount to 12. By clicking on the "Graphic..." button the distribution function is portrayed graphically.



In the "Relative Factors" section, the runoff's factors are defined for single hourly intervals in respect to the average daily runoff.
These factors are overlayed with the factors for the week hydrographs and the day hydrographs.

1.3.3.4 Hydrographs

You can open the eight sub-indexes for the "Hydrographs" element by double-clicking on the element in the element tree.



You enter the name in the "Hydrograph" properties dialog.

Comments
Here you can enter comments if you wish.

Type

In the "Type" section you can choose whether you want to calculate with year and day hydrographs or if a hydrograph should be read from an external file.

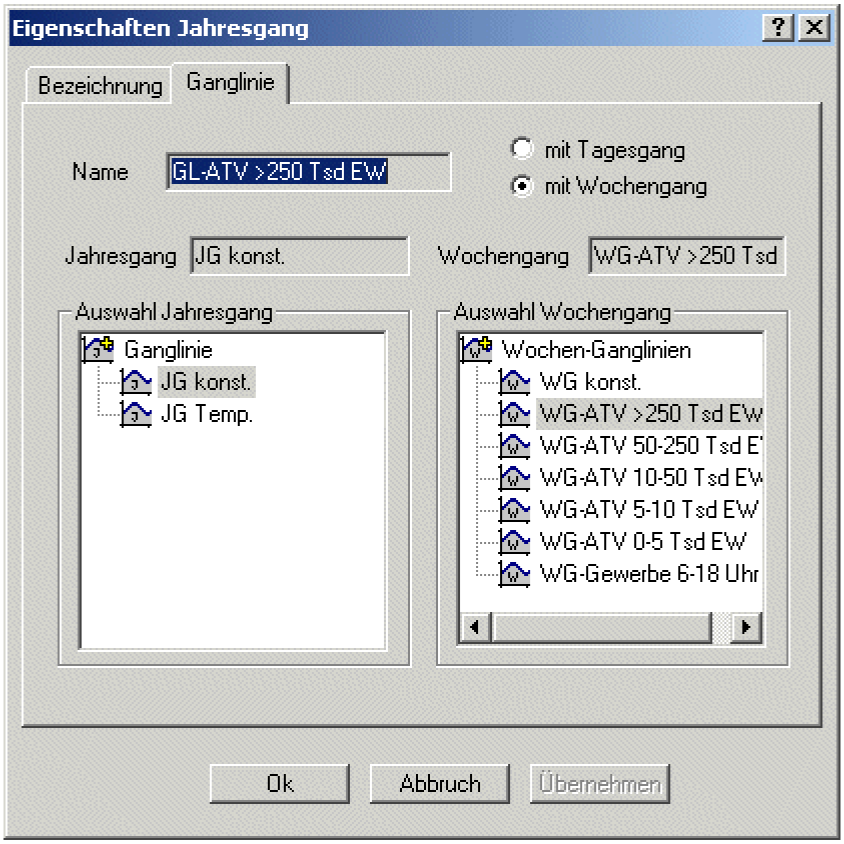


Figure 3-11: "Hydrograph" tab in the hydrograph dialog window In the "Hydrograph" tab of the "Hydrograph" properties dialog you first set whether calculations should be done with a special day hydrograph or with a week hydrograph (compiled from various day hydrographs).

In the section labeled "Choose year gage" you set the year hydrographs. The week hydrograph is selected in the section labeled "Choose week gage". This is overlayed with the day hydrographs.

1.3.3.4.1 Hydrographs: Hydrograph

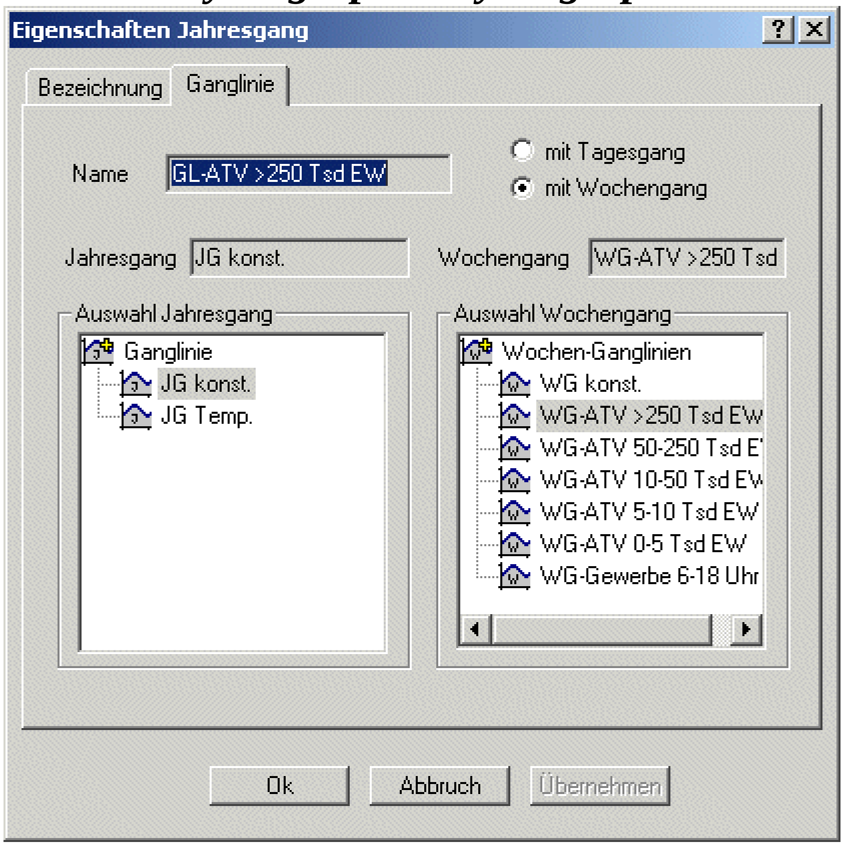


Abbildung 1-51: Dialogfenster Ganglinie des Systemelements „Jahresgang“

Im Eigenschaftsdialog *"Ganglinie"* des Systemelements *"Jahresgang"* wird zuerst festgelegt, ob mit einer speziellen Tagesganglinie oder mit einer Wochenganglinie (zusammengesetzt aus verschiedenen Tageslinien) gerechnet werden soll.
In *„Auswahl Jahresgang“* werden die Jahres-Ganglinien festgelegt.
Die Wochenganglinie wird im Bereich *„Auswahl Wochengang“* ausgewählt. Sie wird mit den Tages-Ganglinien überlagert.

1.3.3.4.2 Hydrograph: File-Import

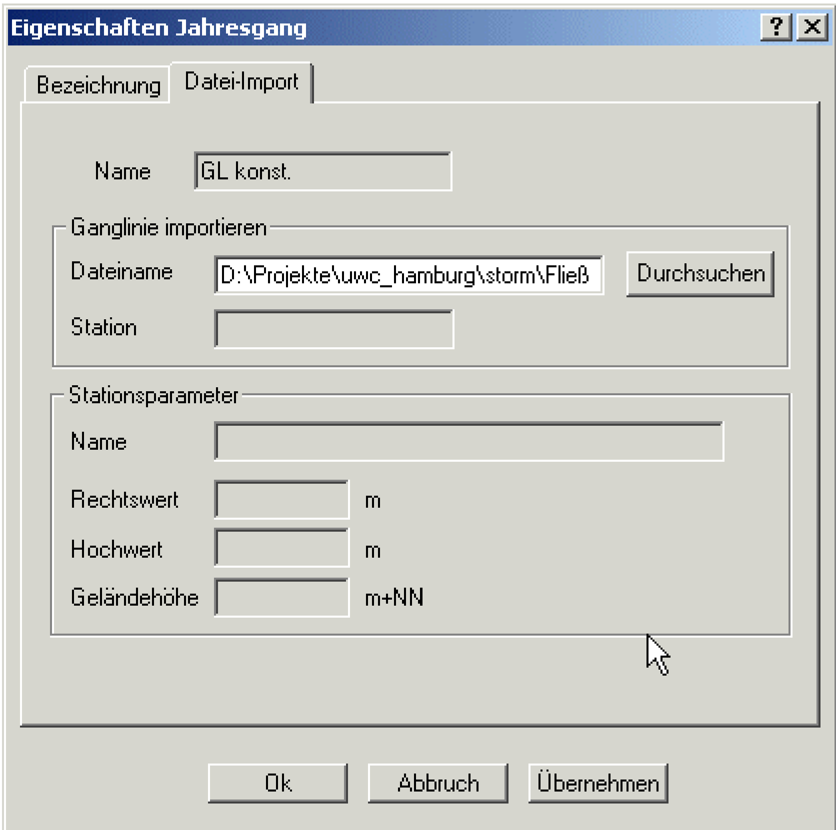
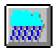


Abbildung 1-52: Eigenschaftendialog "Datei-Import" der Ganglinie

1.3.4 Zeitreihen

1.3.4.1 Rain Gauges

A new rain gauge can be created by clicking on this button , via the context menu with the right mouse button, and via the menu option "Add new..." in the "System Elements" pulldown menu.
To carry out long-term simulation, precipitation data with digitalised records of a longer time frame must be available in the form of a rain file (File format see section 4–1).
In the dialog window "Rain Gauge Properties", such a rain file is assigned to the programme. Use the "Browse" button to do this and select an existing rain file in the "Open" dialog window that appears.

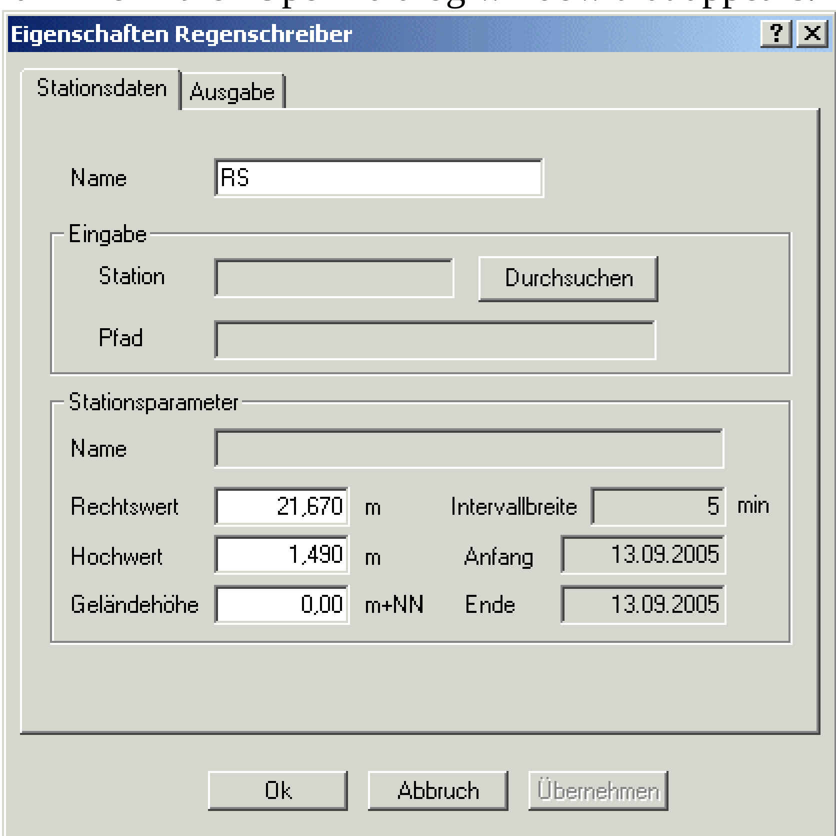
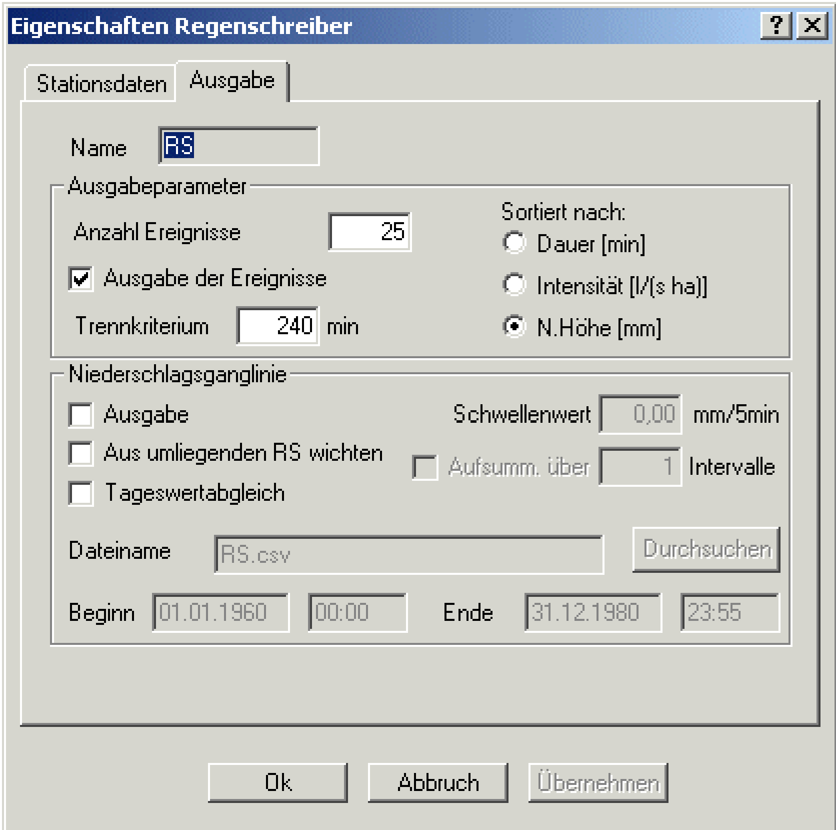


Figure 3-13: Dialog window for entering rain gauge station data

After selecting a rain file, STORM© fills out the "Station parameters" with the data contained in the file (see example in Figure 3-13).
Furthermore, you have the ability to output the precipitation sorted by duration, frequency or amount in a table in the "Output" tab, or to create a precipitation hydrograph in .csv format.



In the "Output" tab you can set a table-like output of precipitation events and an output of hydrographs.

Output Parameters

In the "Output parameters" section, the number of precipitation events is set. The value determines the span of the report output as well as the basis for the statistical analysis.

By clicking on the "Output of events" checkbox you can set whether the precipitation events should be output in the report or not.

The separation criteria determines how large the minimum time between 2 rain events is, i.e. when 2 events count as separate from one another.

The output of the events can be sorted by duration, intensity or precipitation hight.

Precipitation Hydrographs

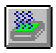
In the "Precipitation hydrograph" section, the output of a precipitation hydrograph can be activated by clicking on the checkbox.

When entering the threshold value, you can suppress the output of zero-values, i.e. periods without precipitation, by entered the lowest value to be reported. For example, you can ennter 0.1 in order to have all events with water levels greater than 0.1 m written to the file.

Indicate a filename for outputting the .csv file (values with commas as separators) or set the location and name of the output with the "Browse" button.

The timestep for outputting the file can be set in the last row with the begin and end times.

1.3.4.2 Evaporation

 In order to take evaporation loss into account, indicating an annual potential total evaporation hight is required in the "Evaporation Properties" dialog.

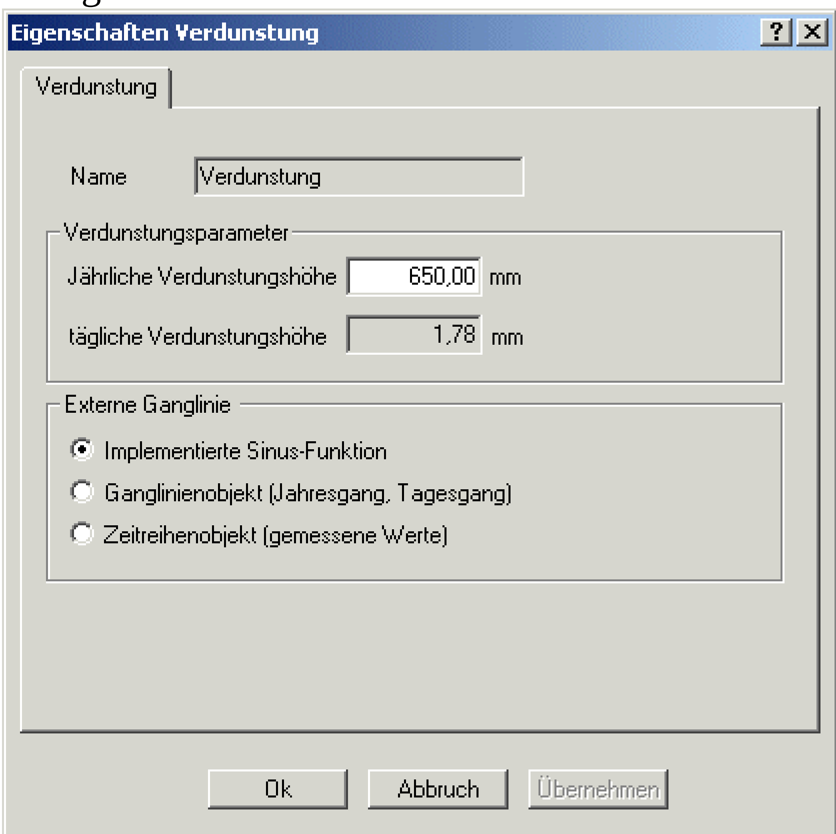


Figure 3-14: Dialog window for entering the evaporation hight

An average day and year hydrograph forms the basis for this potential total evaporation hight (see also section 4–1). In the "Comments" field you can fill in comments about the derivation or source of the evaporation hight entered.

1.3.4.2.1 Evaporation: Hydrograph

Nachdem Sie im Eigenschaftendialog der Verdunstung als Externen Ganglinien Typ das "Ganglinienobjekt" ausgewählt haben

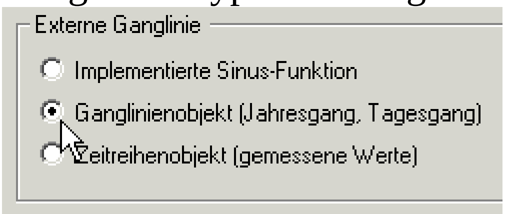


Abbildung 1-57: Auswahl des Ganglinieobjektes

erschein ein zusätzlicher Karteireiter "Ganglinie" im Eigenschaftendialog.

Abbildung 1-58: Zusätzlicher Karteireiter Ganglinie

Wenn Sie auf diesen Karteireiter klicken öffnet sich der Eigenschaftendialog "Ganglinie".

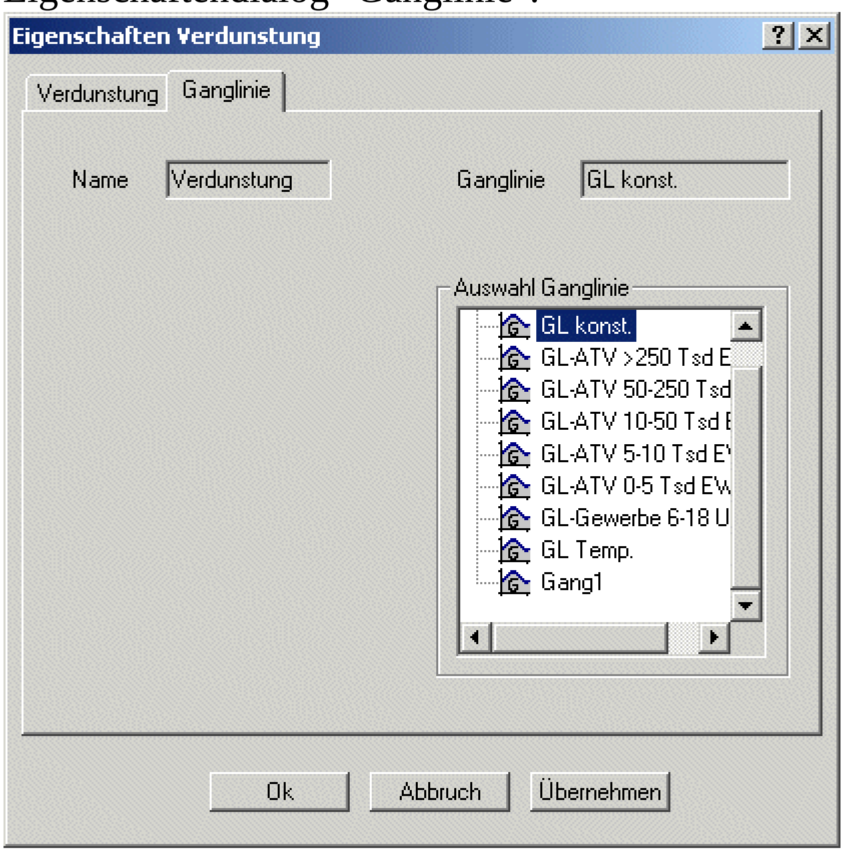


Abbildung 1-59: Zusätzliche Registerkarte "Ganglinie"

In diesem Eigenschaftendialog können Sie im Auswahlbereich die gewünschte Ganglinie auswählen. Die entsprechenden Einstellungen werden von STORMÓ automatisch übernommen.

1.3.4.2.2 Verdunstung: Zeitreihe

Nachdem Sie im Eigenschaftendialog der Verdunstung als Externen Ganglinien Typ das "Zeitreihenobjekt" ausgewählt haben

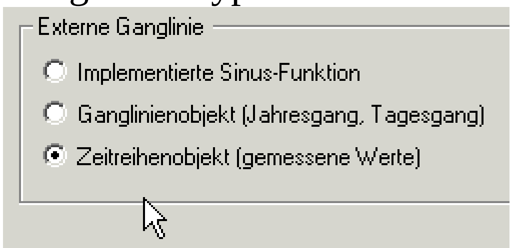


Abbildung 1-60: Auswahl des Zeitreihenobjektes

erschein ein zusätzlicher Karteireiter "Zeitreihe" im Eigenschaftendialog.

Abbildung 1-61: Zusätzlicher Karteireiter Zeitreihe

Wenn Sie auf diesen Karteireiter klicken öffnet sich der Eigenschaftendialog "Zeitreihe".

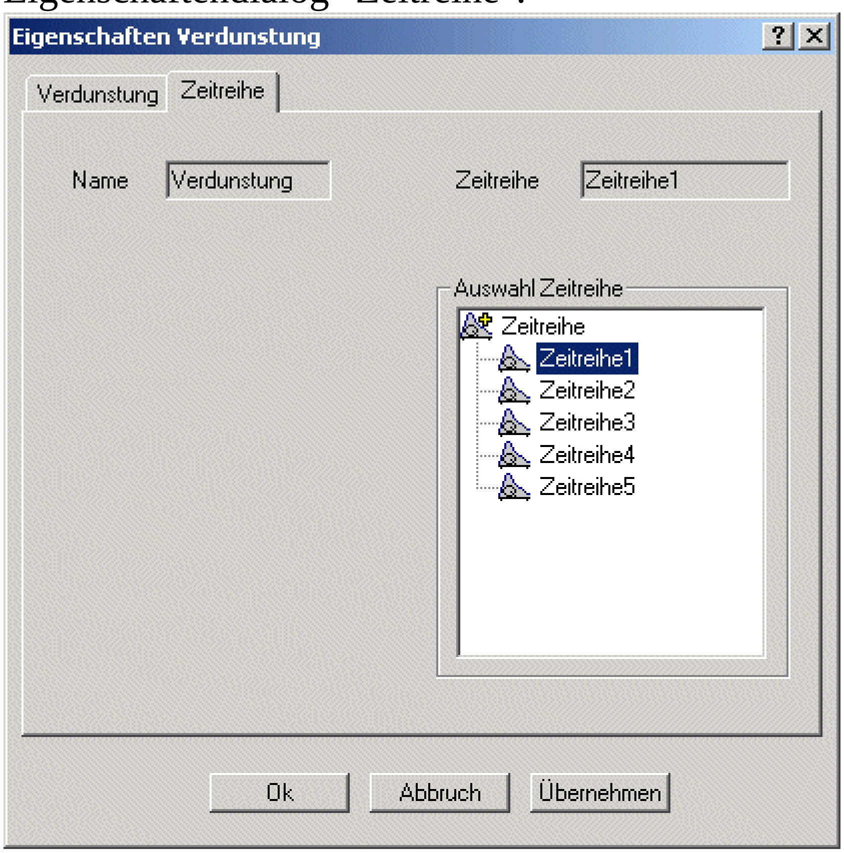


Abbildung 1-62: Zusätzliche Registerkarte "Zeitreihe"

In diesem Eigenschaftendialog können Sie im Auswahlbereich die gewünschte Zeitreihe auswählen. Die entsprechenden Einstellungen werden von STORMÓ automatisch übernommen.

1.3.4.3 Temperature

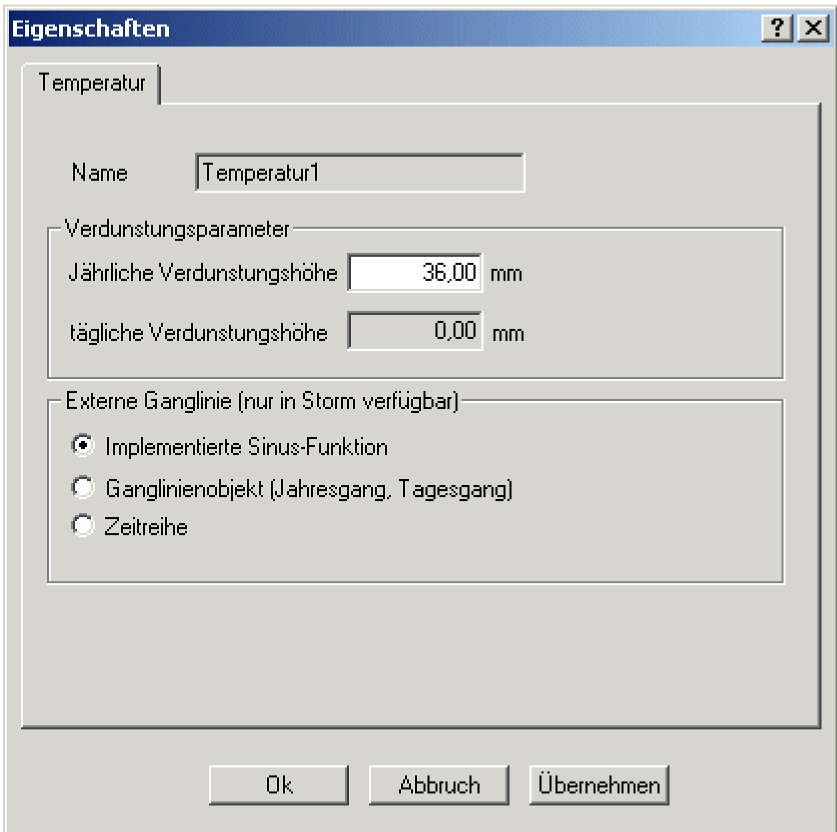


Abbildung 1-63: Eigenschaftendialog der Temperatur

1.3.4.4 Time Series

Eine neue Zeitreihe kann über die abgebildete Symbolschaltfläche , über das Kontextmenü der rechten Maustaste und über den Menüpunkt „Neu hinzufügen“ im Pulldown-Menü „Systemelemente“ erzeugt werden.

Im Dialogfenster „Eigenschaften Zeitreihe“ können Sie den Namen für die Zeitreihe vergeben und die zu verwendenden Daten bestimmen.

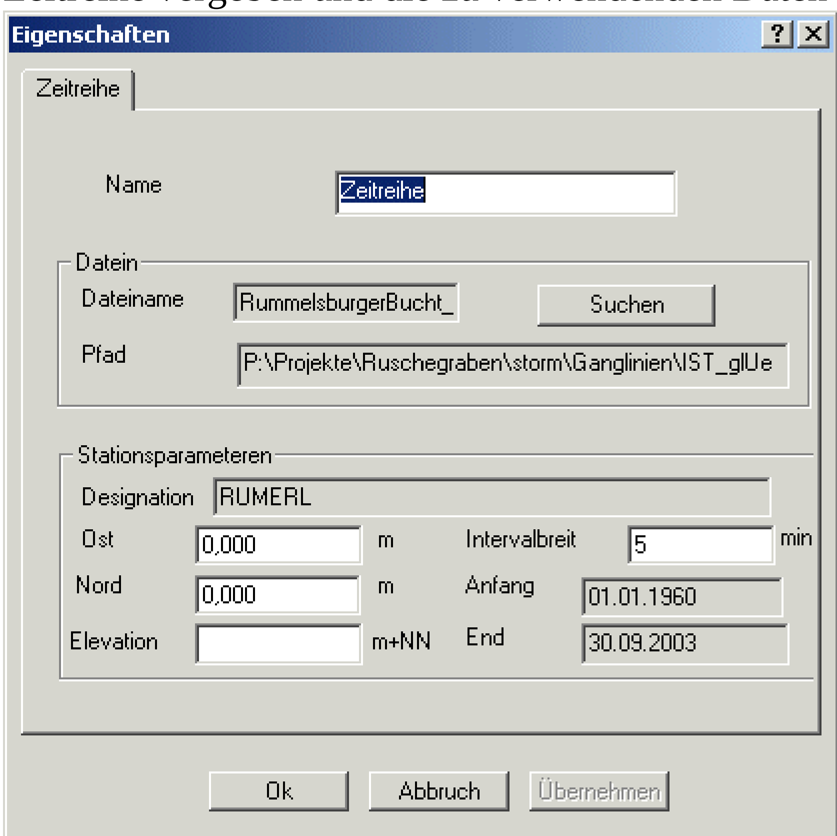


Abbildung 1-64: Eigenschaftendialog der Zeitreihe

Die zu verwendenden Daten können im Bereich ***"Dateien"*** eingestellt werden. STORMÓ fügt die entsprechenden Stationsparameter automatisch im Bereich "Stationsparameter" ein.

1.3.5 Abflussbildungsparameter

Für die Berechnung des Abflusskontinuums ist die richtige Ermittlung abflusswirksamer Anteile der Niederschlagsereignisse von Bedeutung. Für undurchlässige (befestigte) Flächen und für durchlässige (unbefestigte) Flächen sind unterschiedliche Ansätze der Abflussbildung sinnvoll. Bevor die Flächen des Berechnungsmodells eingegeben werden, sind für jede Flächenart Abflussbildungsparametersätze anzulegen.

1.3.5.2 Runoff Formation on Impermeable Surfaces

You can add a new set of runoff formation parameters with this button in the toolbar, via the menu option "Add New..." in the "System Elements" pulldown menu, or via the context menu.
The sets of runoff formation parameters "Flat roof", "Slanted roof", "Courtyard/Pavement", and "Street" have the default values shown in Figure 3-15.

Name	Vben [mm]	Vmuld [mm]	PsiA [-]	PsiE [-]	Regenschreiber
Flachdach	2.00	0.00	1.00	1.00	RS
Steildach	0.30	0.00	1.00	1.00	RS
Hof/Wegeflächen	0.70	1.80	0.00	0.75	RS
Straße	0.50	1.80	0.00	0.95	RS

Figure 3-15: Default values for the predefined sets of runoff formation parameters for impermeable surfaces

Newly added sets of parameters contain defaults shown in Figure 3-16 that should be adjusted to the properties of the newly added surface type.

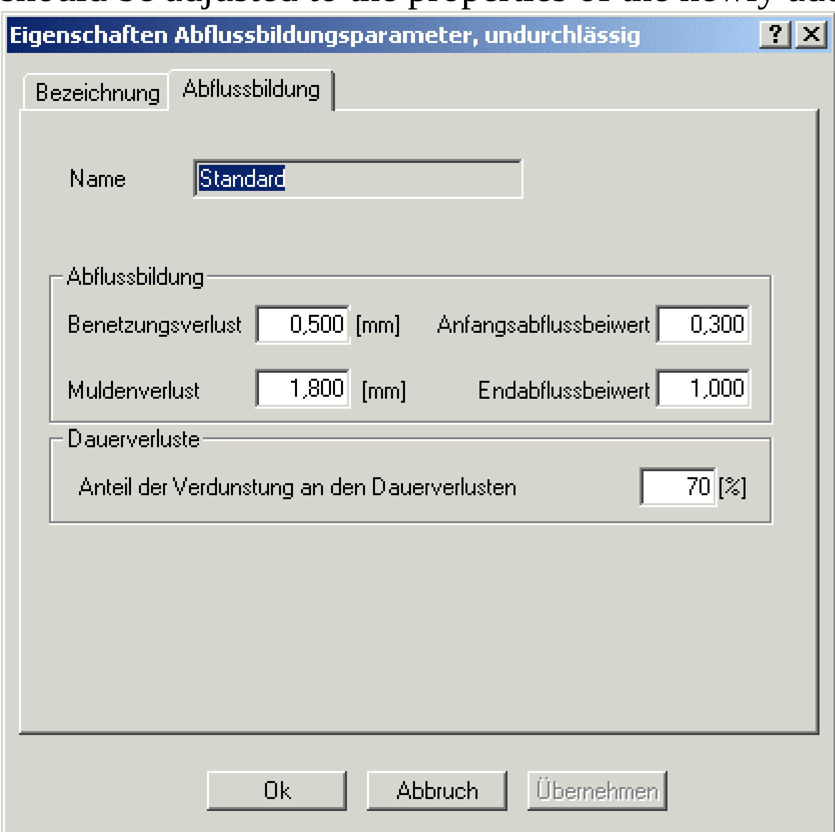


Figure 3-16: Defaults in the "Runoff Formation Parameters Properties" dialog window

In the "Runoff Formation Parameters Properties" dialog window, the wetting loss and swale loss as well as the initial and final runoff coefficients are entered in the "Runoff Formation" tab after entering a name and any comments in the "Designation" tab.

1.3.5.3 Runoff Formation on Permeable Surfaces

You can add new sets of runoff formation parameters for permeable surfaces with this button in the toolbar, via the "Add New..." menu option in the "System Elements" pulldown menu, and via the context menu with the right mouse button.
When describing the properties of permeable surfaces, soil characteristic data should be entered in the set of runoff formation parameters in addition to the parameters for impermeable surfaces described in section 3.6.1.

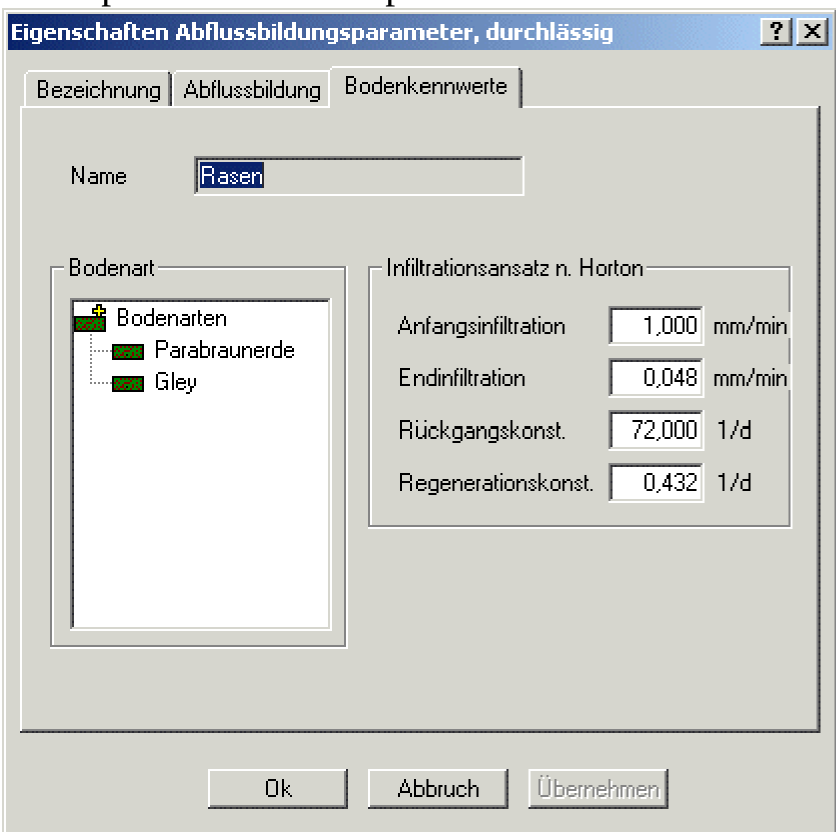


Figure 3-18: Entering the soil characteristic data for permeable surfaces

In the "Soil characteristics" tab, you should click on a soil type whose properties (infiltration and utilisable field capacity) are to be taken into account in the set of runoff formation parameters (see example in Figure 3-18). The infiltration-calculation can deviate from the soil type's other properties.

1.3.5.3 Abflussbildung für Flächen mit dezentraler Regenwasserbewirtschaftung

Das Anlegen von Abflussbildungsparametersätzen für dezentrale Regenwasserbewirtschaftung erfolgt mit dem über die rechte Maustaste erreichbaren Kontextmenü bzw. mit der hier abgebildeten Symbolschaltfläche in der Symbolleiste.
Bei der Beschreibung der Eigenschaften von Flächen mit dezentraler RWB treten folgende Eigenschaftendialoge auf:

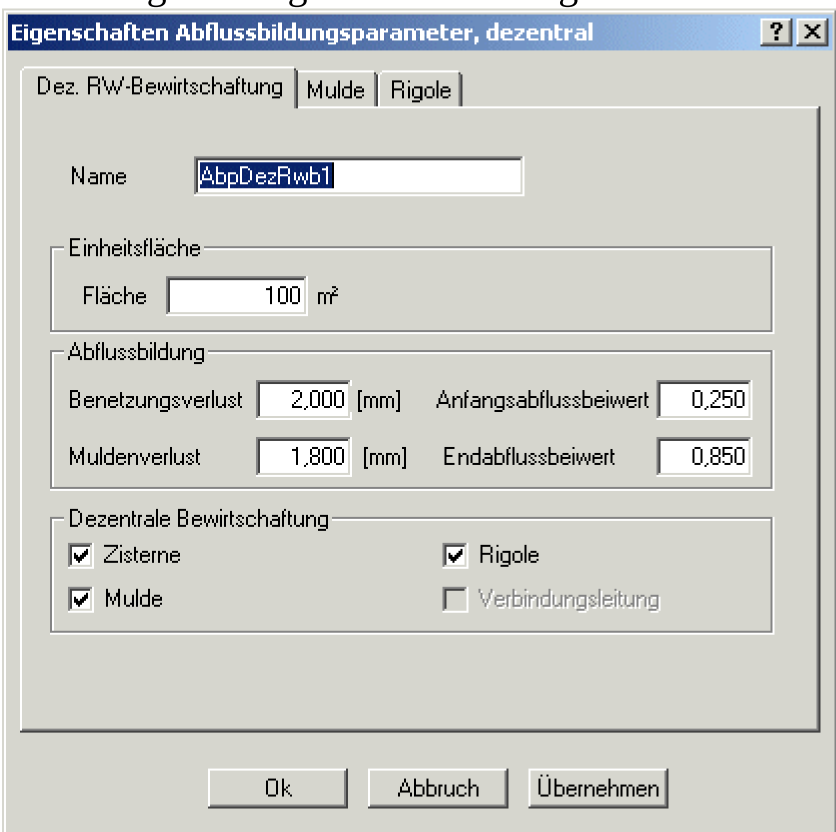


Abbildung 1-68: Erfassung der dezentralen RWB für die Flächen

Im Eigenschaftsdialogfeld "Dezentrale Regenwasserbewirtschaftung" geben Sie die erforderlichen Werte für Namen, Fläche, Abflussbildung und die dezentrale Bewirtschaftung ein.
Im Bereich ***"Einheitsfläche"*** können Sie die Flächengröße in m² festlegen.
Im Bereich ***"Abflussbildung"*** können Sie die vordefinierten Parameter

- *Benetzungsverlust*
- *Muldenverlust*
- *Anfangsabflussbeiwert und*
- *Endabflussbeiwert*

angeben.
Sie können aber auch eigene Werte eingeben und damit die vordefinierten Werte überschreiben.
Abschliessend können Sie im Bereich ***"Dezentrale Bewirtschaftung"*** auswählen welche Regenwasserbewirtschaftungselemente Sie benutzen wollen. Für den Fall dass Sie Mulden und/oder Rigolen zur Bewirtschaftung nutzen, müssen Sie außerdem in weiteren Registerkarten die Einstellungen für die jeweiligen Elemente vornehmen.

1.3.5.3.1 Swale

Wenn Sie im Eigenschaftendialog "Dezentrale Regenwasserbewirtschaftung" als Bewirtschaftung "Mulde" aktiviert haben, öffnet sich diese zusätzliche Registerkarte "Mulde", in der Sie weitere Angaben zum verwendeten Entwässerungselement machen können.

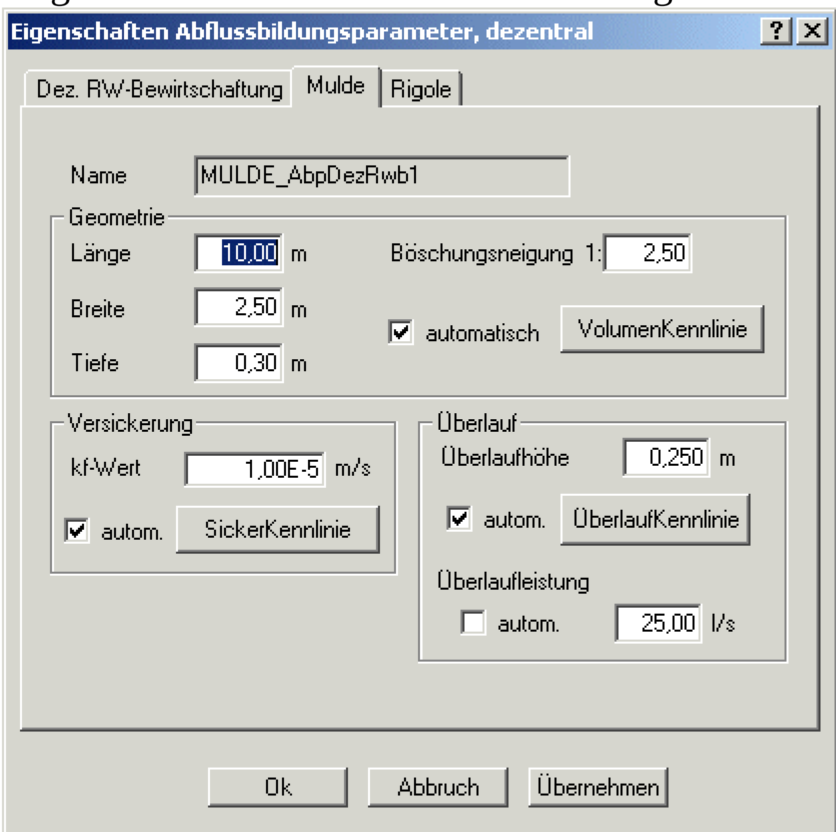


Abbildung 1-69: Erfassung der Muldendaten für die dezentralen RWB

In diesem Dialog können Sie in den vier Bereichen Angaben zu Namen, Geometrie, Versickerung und Überlauf der Mulde machen.
Für die Geometrie der Mulde müssen Sie Angaben zu Länge, Breite, Tiefe (in m) und Böschungsneigung machen. Die Böschungsneigung wird dabei als Verhältnis von 1 zu Wert angegeben (in Abbildung 1-69: "1/2,5").
Für die Versickerung reicht die Angabe des kf-Wertes in m/s und für den Überlauf reicht die Überlaufhöhe in m. Die Überlaufleistung wird in der Regel automatisch berechnet, kann jedoch manuell überschrieben werden, wenn Sie vorher den Hacken im Feld "automatisch" entfernen.
Durch ein Häckchen im Feld "automatisch" können Sie die entsprechenden Kennlinien (Volumne-, Sicker- und Überlauf-kennlinie) von STORMÓ

berechnen lassen.

1.3.5.3.2 Trench

Wenn Sie im Eigenschaftendialog "Dezentrale Regenwasserbewirtschaftung" als Bewirtschaftung "Rigole" aktiviert haben, öffnet sich diese zusätzliche Registerkarte "Rigole", in der Sie weitere Angaben zum verwendeten Entwässerungselement machen können.

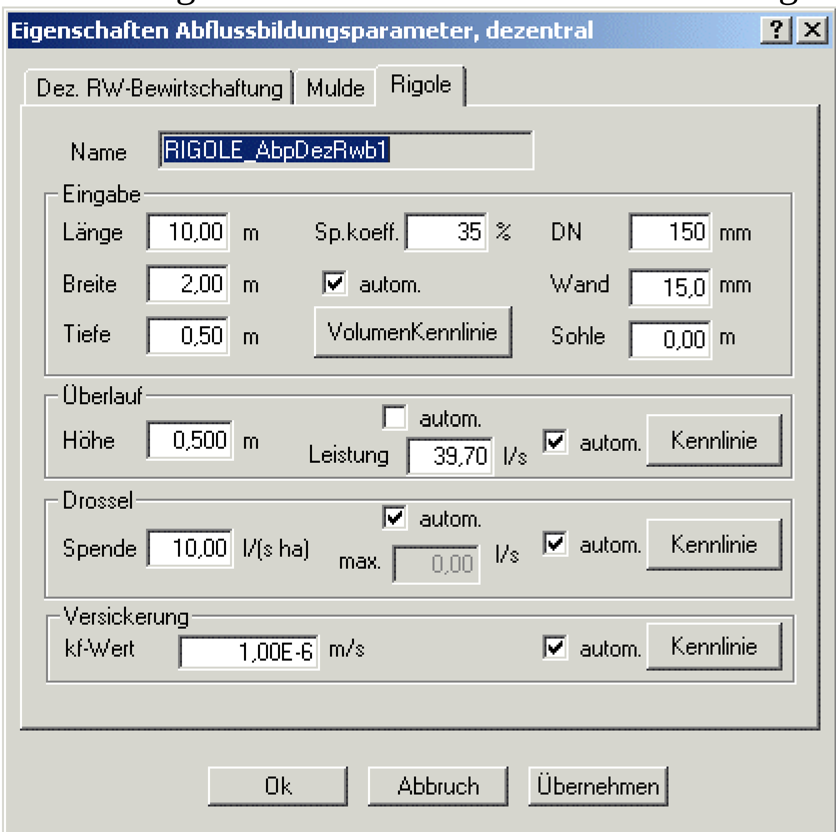


Abbildung 1-70: Erfassung der Rigolendaten für die dezentralen RWB

In diesem Dialog können Sie in den fünf Bereichen Angaben zu Namen, Geometrie, Versickerung, Drossel und Überlauf der Rigole machen.

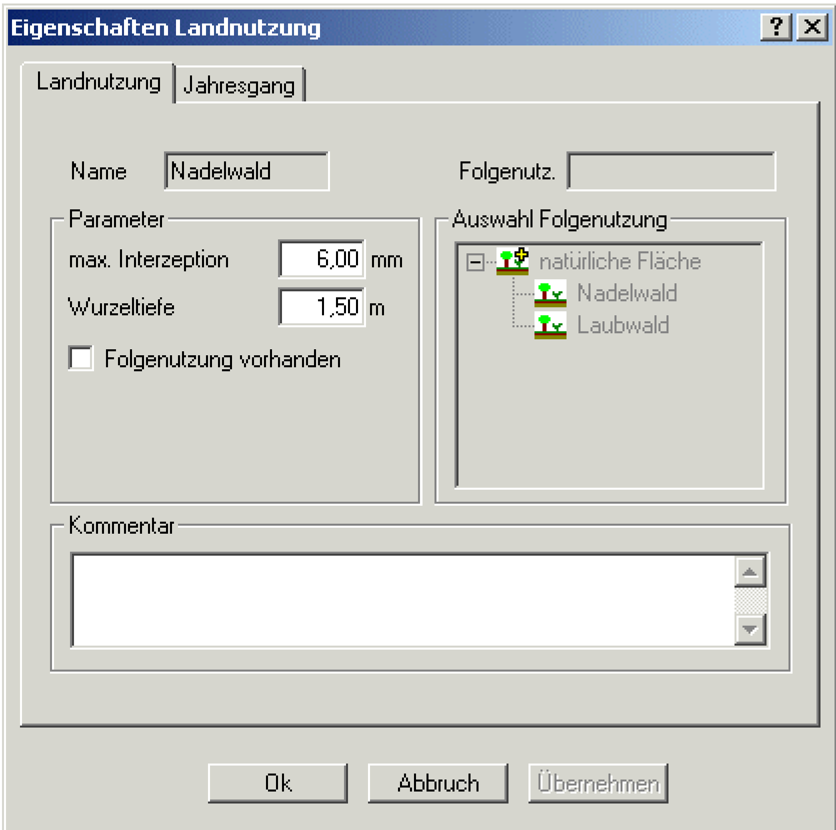
Für die Geometrie der Rigole müssen Sie Angaben zu Länge, Breite, Tiefe (in m) machen. Weiterhin können Sie den Speicherkoeffizienten in Prozent angeben und Dicke (Wand) und Durchmesser (DN) des Dränrohres in mm festlegen. Als letzte Angabe können Sie die Sohlhöhe der Rigole in Metern bestimmen.

Für die Versickerung reicht die Angabe des kf-Wertes in m/s, für den Überlauf reicht die Überlaufhöhe in m und für die Drossel reicht die Angabe der Drosselspende in l/(s ha). Die Überlaufleistung und die maximale Drosselleistung werden in der Regel automatisch berechnet, können jedoch manuell überschrieben werden, wenn Sie vorher den Hacken im Feld "automatisch" entfernen.

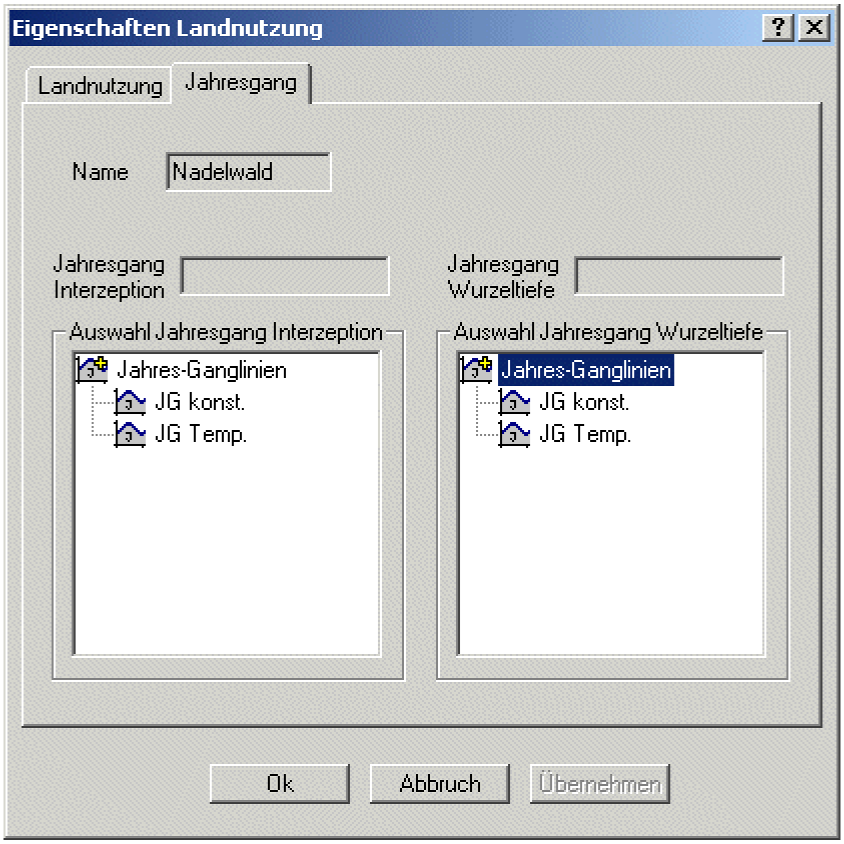
Durch ein Häckchen im Feld "autom." können Sie die entsprechenden Kennlinien von STORMÓ berechnen lassen.

1.3.5.4 Runoff Formation on Natural Surfaces

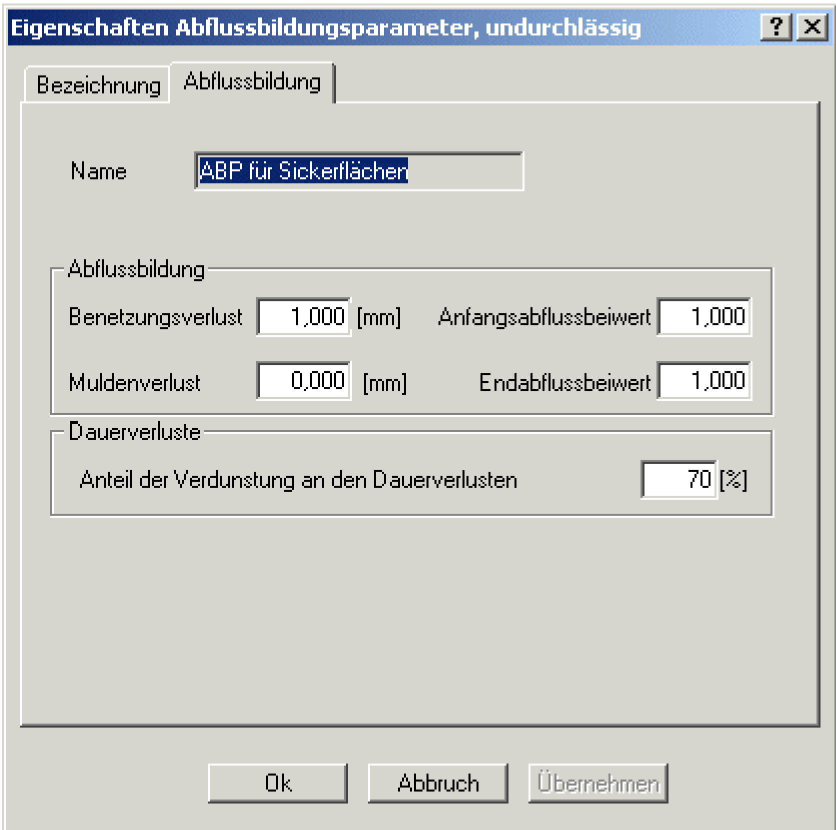
1.3.5.4.1 Land Usage



1.3.5.4.2 Year Gauge



1.3.5.5 Runoff Formation for Infiltration Surfaces



1.3.6 Bodenparameter

Durch einen Doppelklick auf den Begriff „Bodenparameter“ öffnen sich die zwei Unterpunkte Bodentypen und Bodenwasserhaushalt.

1.3.6.1 Soil Types

The soil layer is described in the "Soil Type Properties" dialog. For each soil type, a hydraulic conductivity (Kf-value), a utilisable field capacity (nfK) and an infiltration calculation should be assigned. Later a soil type is assigned to all drainage elements for infiltration.
The properties of several soil types are given as default values as displayed in Figure 3-19. These values can be changed if need be.

Figure 3-19: Default values for predefined soil types

Newly added soil types contain default soil characteristic values corresponding to those of silt. These soil characteristic values should be adjusted to properties of the newly added soil type in the dialog window.

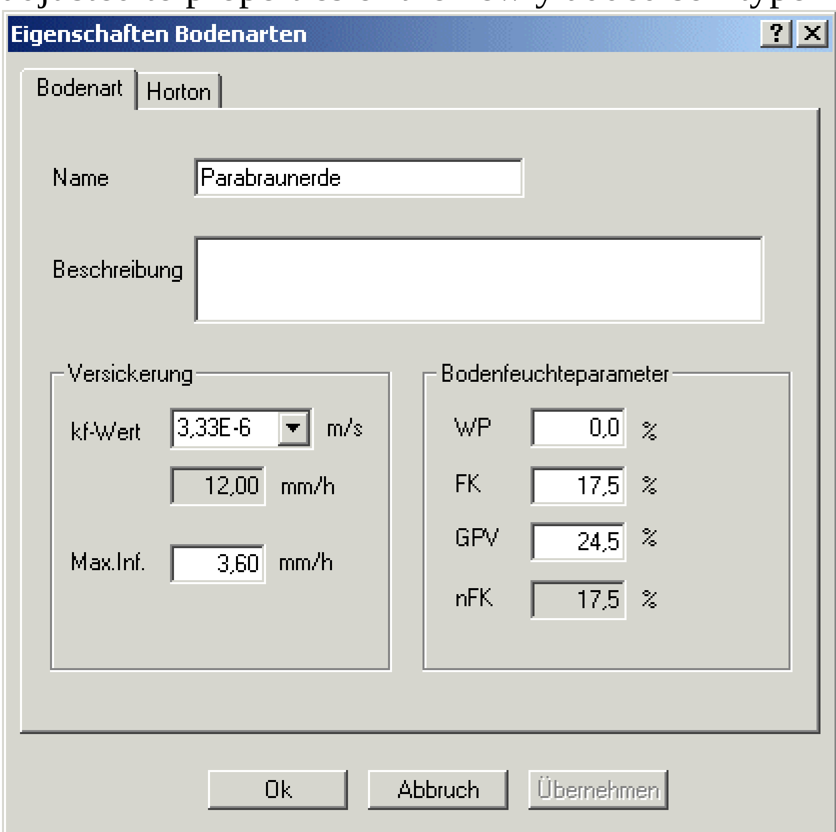
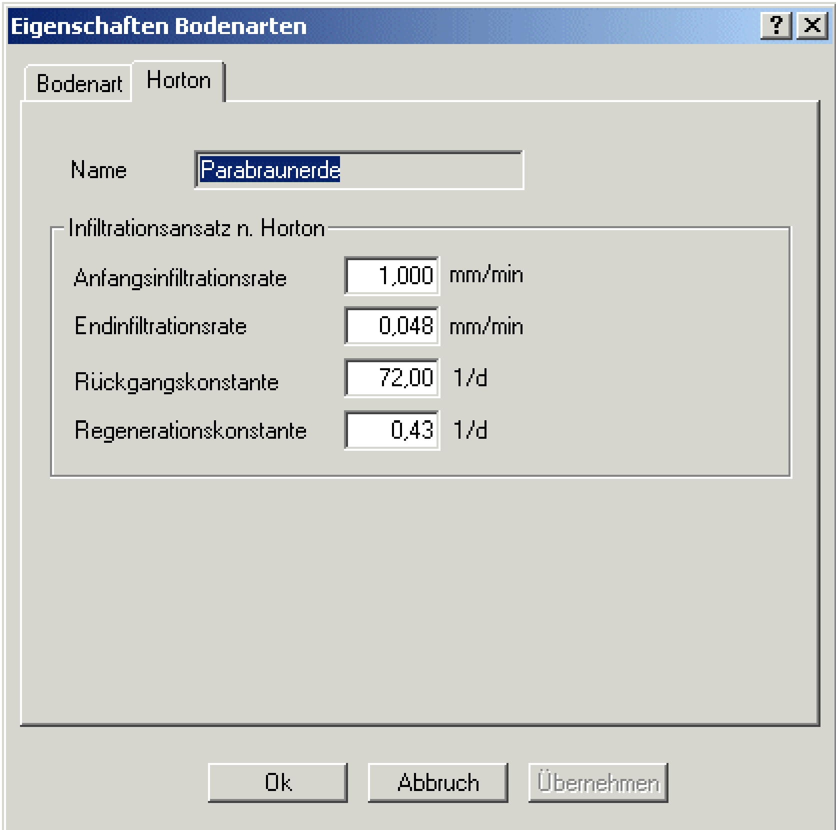


Figure 3-20: Dialog window for entering soil characteristic values

All entires are checked for plausibility. If the values are too large or too small, you'll receive an error message. If unusual values are used, a warning is issued. The technical terms used in the dialog windows are explained in section 6.4.


Eigenschaften Bodenarten
Bodenart
Horton
Name
Parabraunerde
Infiltrationsansatz n. Horton
Anfangsinfiltrationsrate
1,000
mm/min
Endinfiltrationsrate
0,048
mm/min
Rückgangskonstante
72,00
1/d
Regenerationskonstante
0,43
1/d
Ok
Abbruch
Übernehmen

1.3.6.1.1 Horton

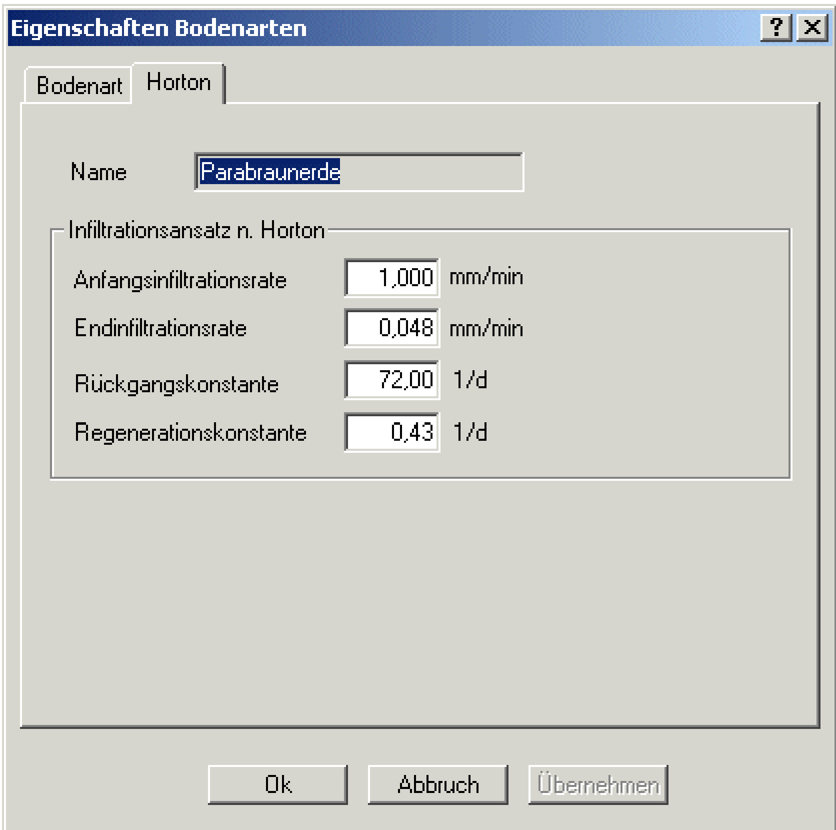


Abbildung 1-76: Eigenschaftendialog "Abflussbildung" für Sickerflächen

1.3.6.2 Soils

1.3.6.2 Schichten

Im Eigenschaftendialog "Schichten" definieren Sie die Schichteigenschaften der Bodenparameter.

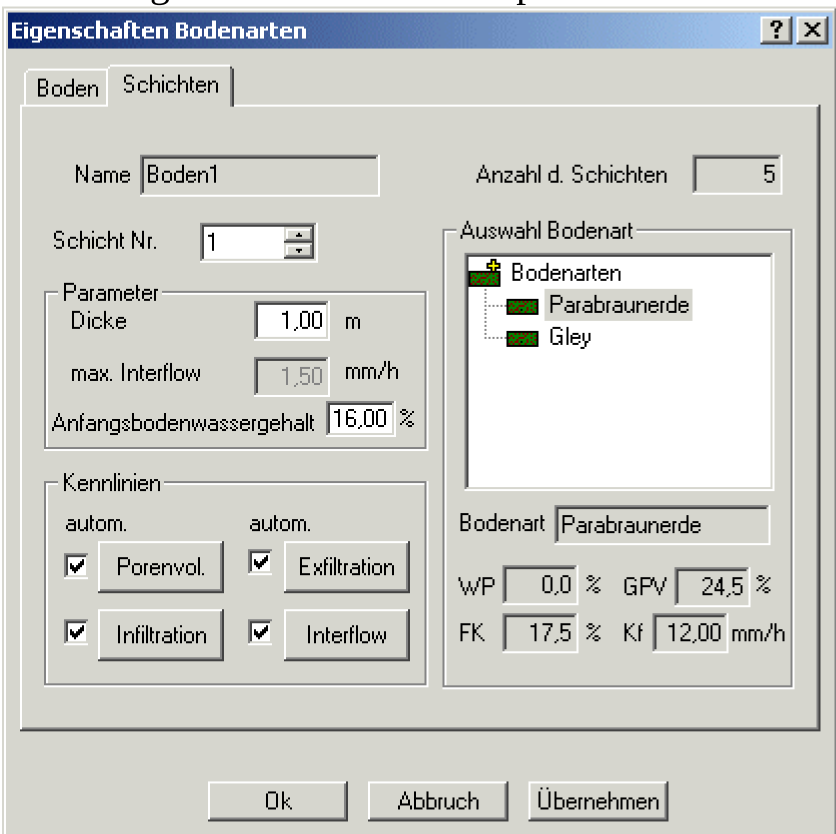
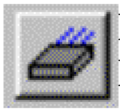


Abbildung 1-78: Eigenschaftendialog "Schichten" für Bodenparameter In der linken und rechten oberen Ecke des Dialoges werden der Name und die Anzahl der Schichten angezeigt, die im Eigenschaftendialog ***"Boden"*** für dieses Element festgelegt wurden. Sie können für jede einzelne Schicht einen eigenen Parametersatz definieren. Das Auswahlkästchen ***"Schicht Nr."*** ermöglicht es Ihnen zwischen den einzelnen Schichten zu wechseln und so den zu bearbeitenden Parametersatz auszuwählen.

Die Parameter die Sie einstellen können finden Sie im Bereich ***"Parameter"***. Sie können hier die Dicke, den maximalen Interflow, den Anfangsbodenwassergehalt und die Bodenart der Schicht festlegen. Hierbei ist die Einstellung des maximalen Interflow nur möglich, wenn Sie vorher in der Registerkarte *"Boden"* unter Interflowberechnung *"Direkt"* ausgewählt haben.

Im Bereich ***"Kennlinien"*** können Sie die jeweilige Kennlinie bearbeiten, beziehugsweise angeben ob sie automatisch berechnet werden soll oder nicht.

1.3.7 Flächen



Mit dieser Symbolschaltfläche in der Symbolleiste, über den Menüpunkt „Neu hinzufügen“ im Pulldown-Menü „Systemelemente“ sowie über das Kontextmenü (rechte Maustaste) können neue Flächen angelegt werden.

Alle Teilflächen gehen in die Summe der angeschlossenen, abflusswirksamen Flächen ein und werden bei der Vordimensionierung und der Abflussbildung berücksichtigt. Neben der Größe der Fläche ist anzugeben, welcher Regenschreiber und welcher zuvor angelegte Abflussbildungsparametersatz verwendet werden soll.

Die Angabe des Entwässerungszieles ist unter Umständen erst später möglich, wenn alle Entwässerungselemente erfasst worden sind.

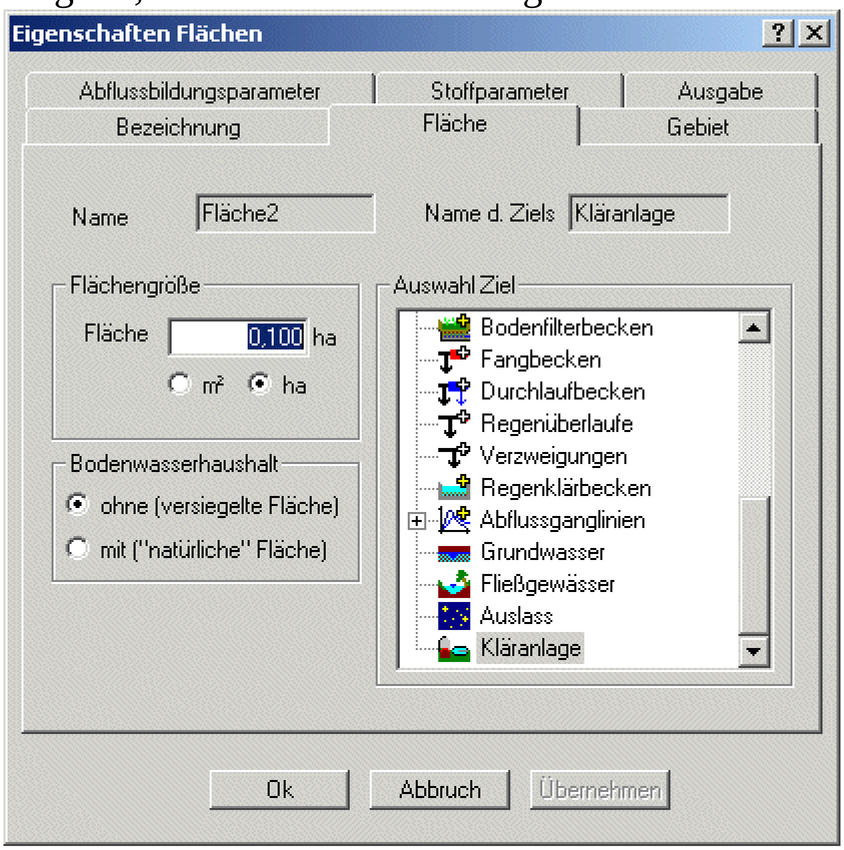
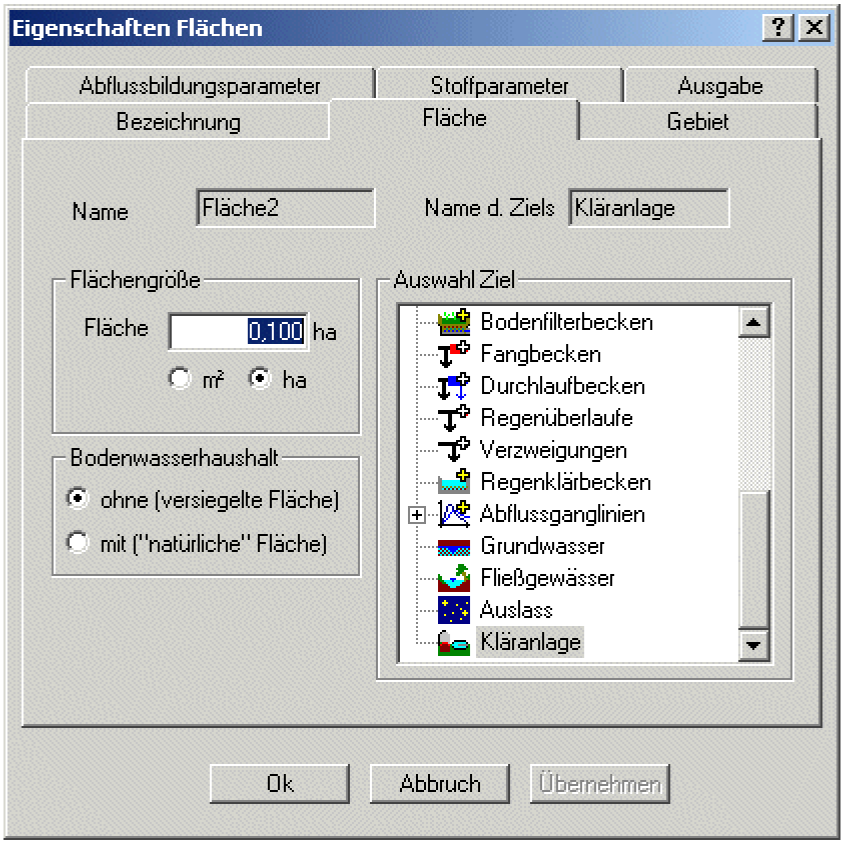


Abbildung 3-22: Auswahl des Entwässerungszieles im Dialog „Eigenschaften Flächen“

Im hier gezeigten Beispiel wurden bereits Mulden als Entwässerungsziel eingegeben (am Symbol +erkennbar, das angeklickt werden kann, um die erfassten Mulden sichtbar zu machen), entwässert wird jedoch ins Grundwasser.

1.3.7.1 Surface Properties: Surface Tab

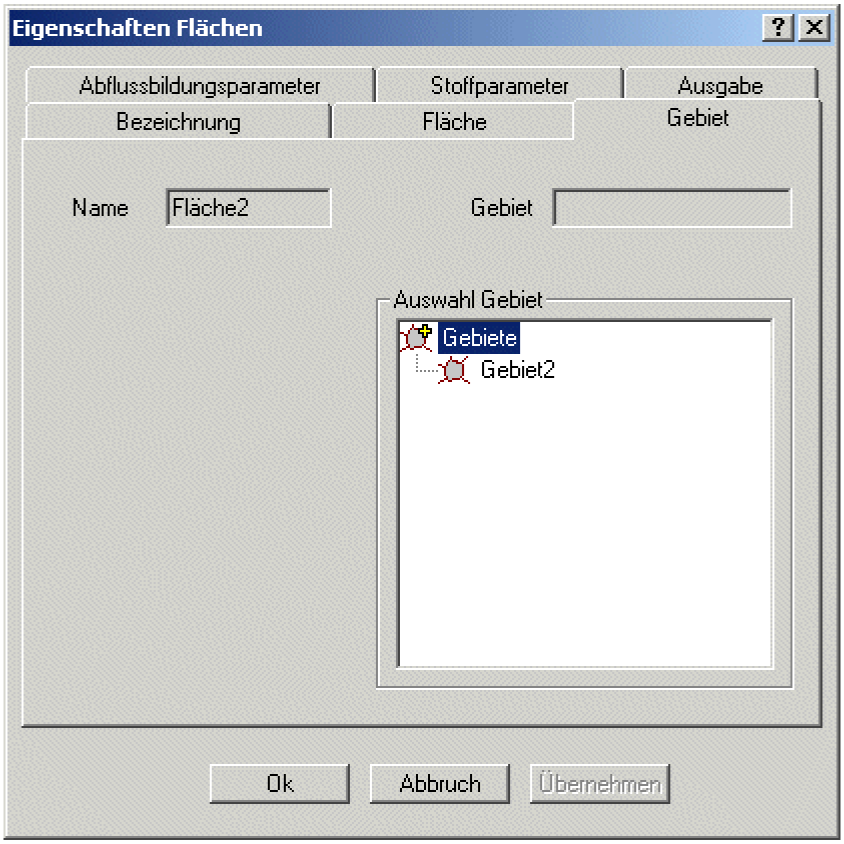


In the "Surface" tab of the Surface Properties, you can enter the size and drainage destination for the surface.

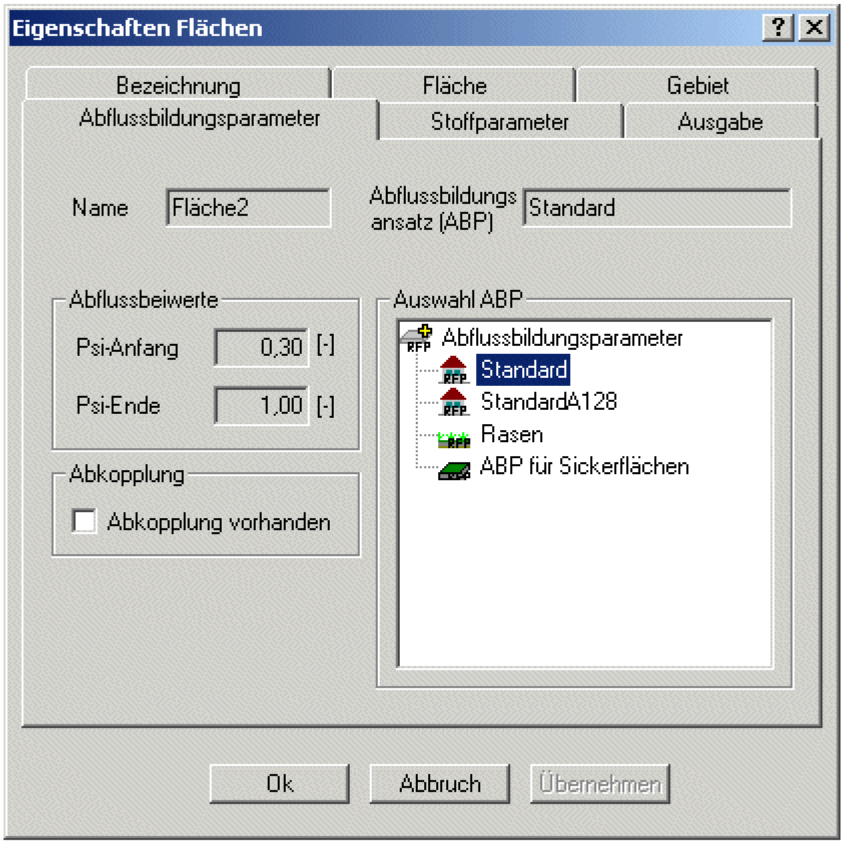
Surface
In the "Surface" input field you can indicate the surface area either in mē or ha.

Choose Destination
In the section titled "Choose Destination" you select the drainage destination with a simple mouseclick. The destination is arbitrary.

1.3.7.2 Surface Properties: Catchment Tab



1.3.7.3 Surface Properties: Runoff Formation Parameters



In the "Runoff Formation Parameters" tab you can assign a valid runoff formation calculation to a surface.

Choose RFC

In the section labeled "Choose RFC" you select one of the pre-defined runoff formation calculations.

1.3.7.4 Eigenschaften Flächen: Abkopplung

Wenn Sie im Eigenschaftendialog "Abflussbildungsparameter" für das Systemelement Fläche im Bereich Abkopplung "Abkopplung vorhanden" aktiviert haben, erscheint die zusätzliche Registerkarte "Abkopplung".

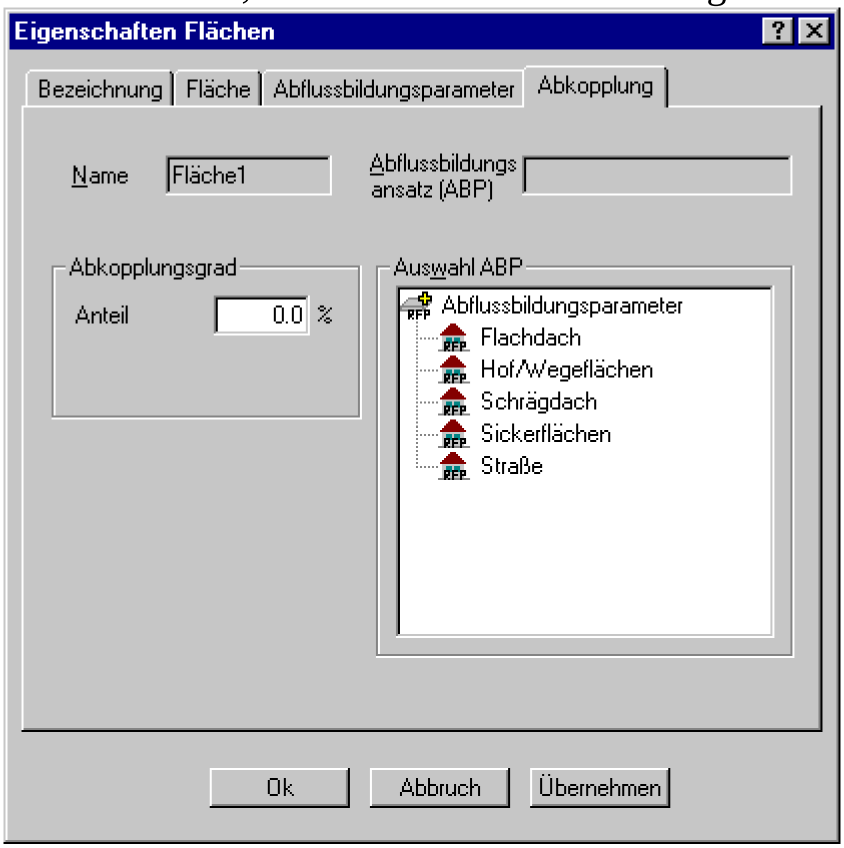


Abbildung 1-82: Eigenschaftendialog "Abkopplung" für das Systemelement Fläche

In diesem Dialog können Sie die Abkopplungsparameter eingeben. Legen Sie den Abkopplungsgrad in Prozent fest und bestimmen Sie den zu benutzenden Abflussbildungsparametersatz im betreffenden Auswahlbereich.

1.3.7.5 Surface Properties: Soil

1.3.7.6 Eigenschaften Flächen: Landnutzung

In diesem Eigenschaftendialog legen Sie die Landnutzung des Flächenelementes fest.

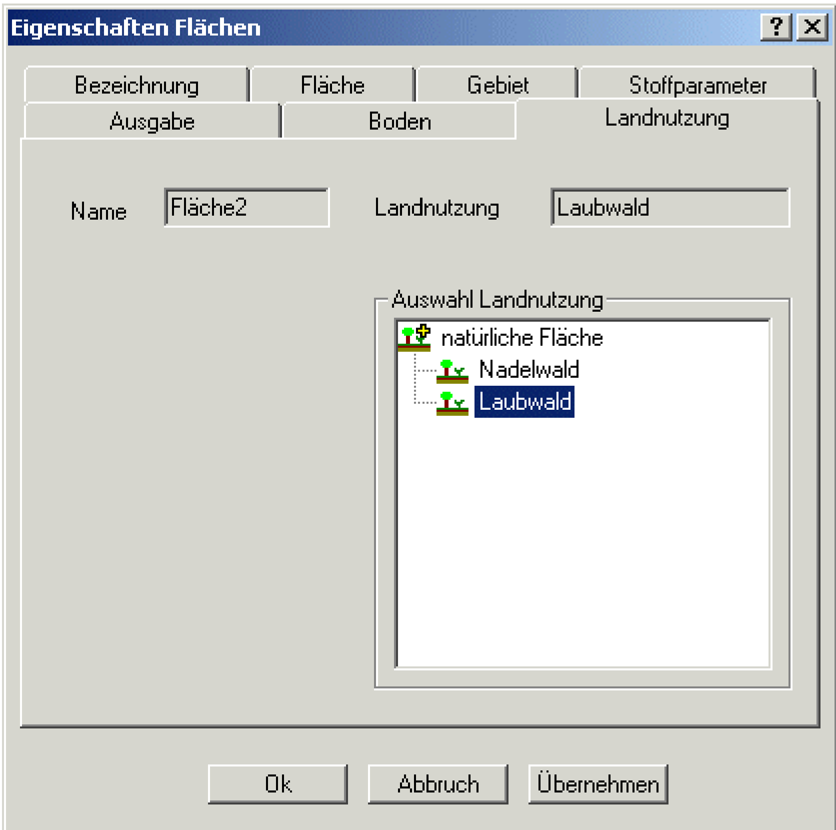
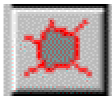


Abbildung 1-84: Eigenschaftendialog "Landnutzung" für das Systemelement Fläche Dieser Dialog wird ebenso wie der Eigenschaftendialog "Boden" erst sichtbar, wenn Sie in der Registerkarte "Fläche" im Bereich Bodenwasserhaushalt die Option "mit natürlicher Fläche" aktiviert haben.

Im Bereich "Auswahl Landnutzung" können Sie den gewünschten Landnutzungsparametersatz auswählen, der der Fläche zugeordnet werden soll.

1.3.7.7 Substance Parameters

1.3.8 Gebiete

Mit dieser Symbolschaltfläche in der Symbolleiste, über den Menüpunkt „Neu hinzufügen“ im Pulldown-Menü „Systemelemente“ sowie über das Kontextmenü (rechte Maustaste) können neue Gebiete angelegt werden.

Alle Gebiete gehen in die Summe der angeschlossenen, abflusswirksamen Flächen ein und werden bei der Vordimensionierung und der Abflussbildung berücksichtigt. In den Gebieten werden zusammengehörende Teilflächen zusammengefasst.

Die Angabe des Entwässerungszieles ist unter Umständen erst später möglich, wenn alle Entwässerungselemente erfasst worden sind.

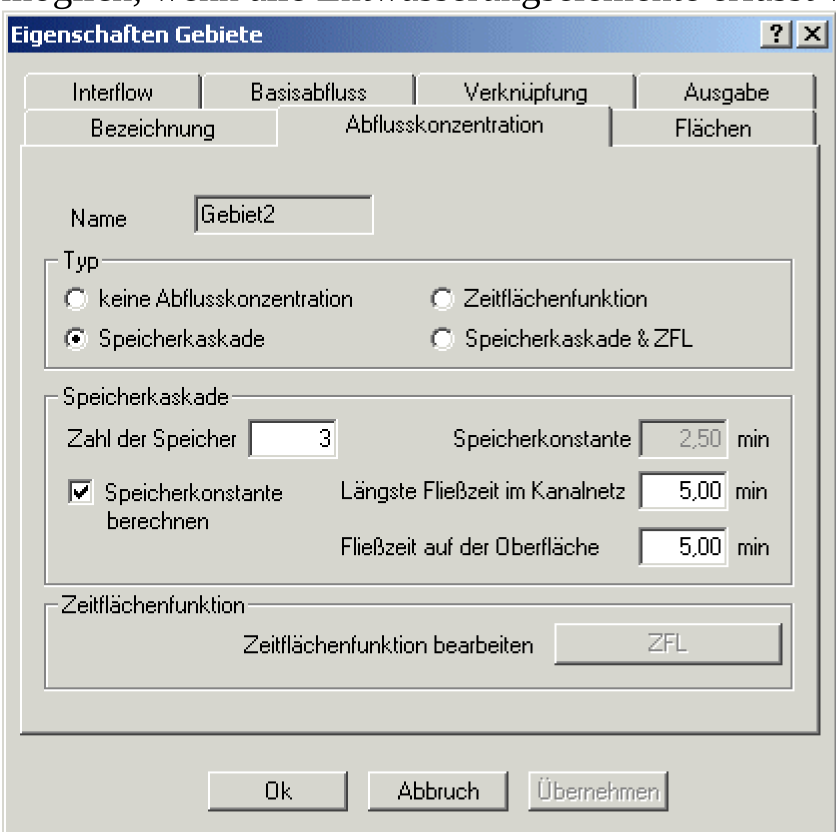


Abbildung 3-23: Festlegung der Berücksichtigung der Abflusskonzentration im Dialog „Abflusskonzentration“

Im Eigenschaftsdialogfeld “Abflusskonzentration” können Sie das Abflussverhalten des Gebietes festlegen. Dies beeinflusst die Abflussdauer im Netz.

Im Bereich “Typ” wählen Sie aus, ob eine Abflusskonzentration berücksichtigt werden soll. Im Falle der Auswahl Speicherkaskade können Sie weitere Parameter im Bereich “Speicherkaskade” festlegen.
Im Bereich “Speicherkaskade” legen Sie folgende Parameter fest.
Im Bereich „Zahl der Speicher“ legen Sie die Speicheranzahl fest, die die Abflussdauer und damit die “Abflusskonzentration” beeinflussen.
Durch Klicken des Häkchens können Sie auswählen, ob Sie die Speicherkonstante für den Speicher in min. direkt angeben wollen oder ob diese aus der Fließzeit im Kanalnetz und der Fließzeit auf der Oberfläche errechnet werden soll.

1.3.8.1 Catchment Properties: Runoff Concentration Tab

In the "Runoff Concentration" tab in the "Catchment Properties" dialog you can set the runoff behaviour for the catchment. This influences the runoff duration in the network.

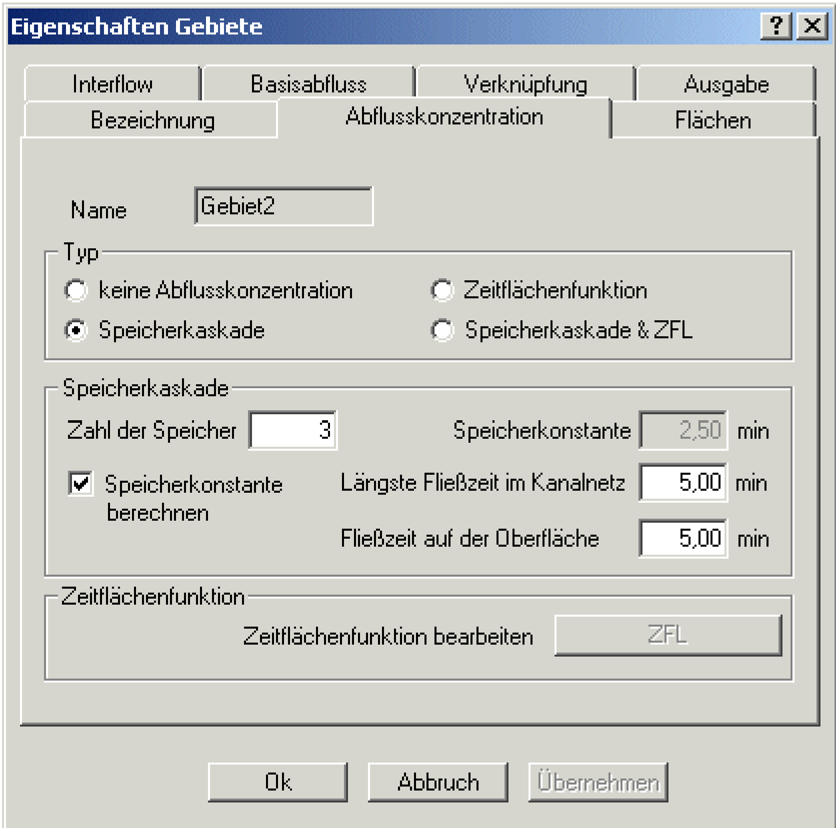


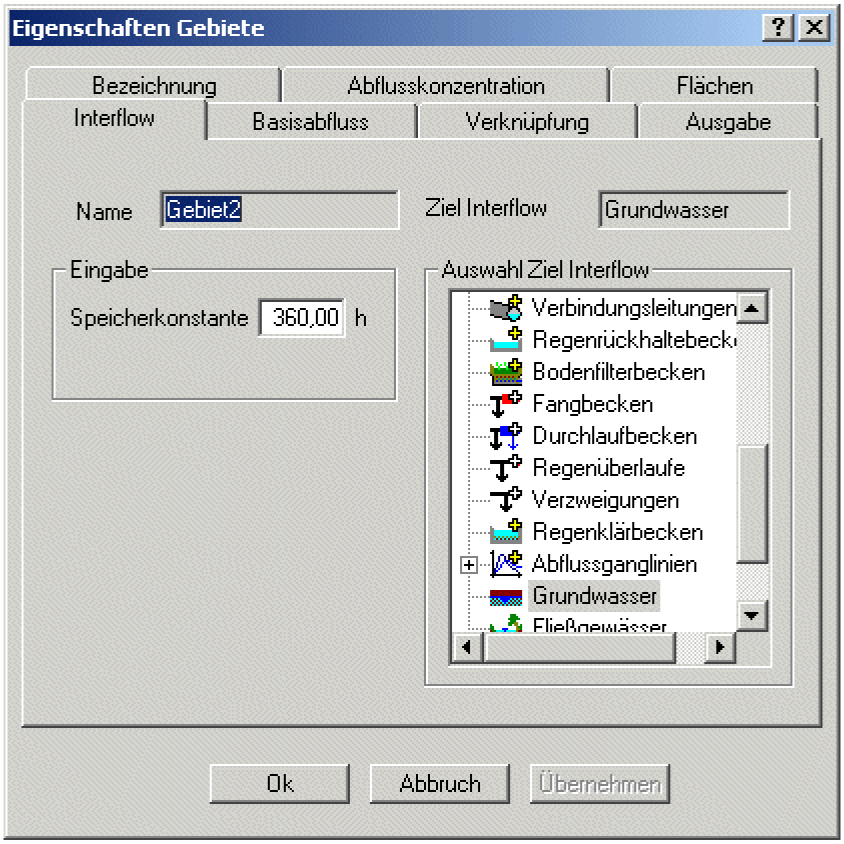
Figure 3-23: Settings for taking the runoff concentration into account in the "Runoff Concentration" tab In the ***"Type"*** section you select whether runoff concentration should be taken into account. If you choose "Storage cascade" you can set further parameters in the section labled "*Storage Cascade*".

In the ***"Storage Cascade"*** section you can set the following parameters:

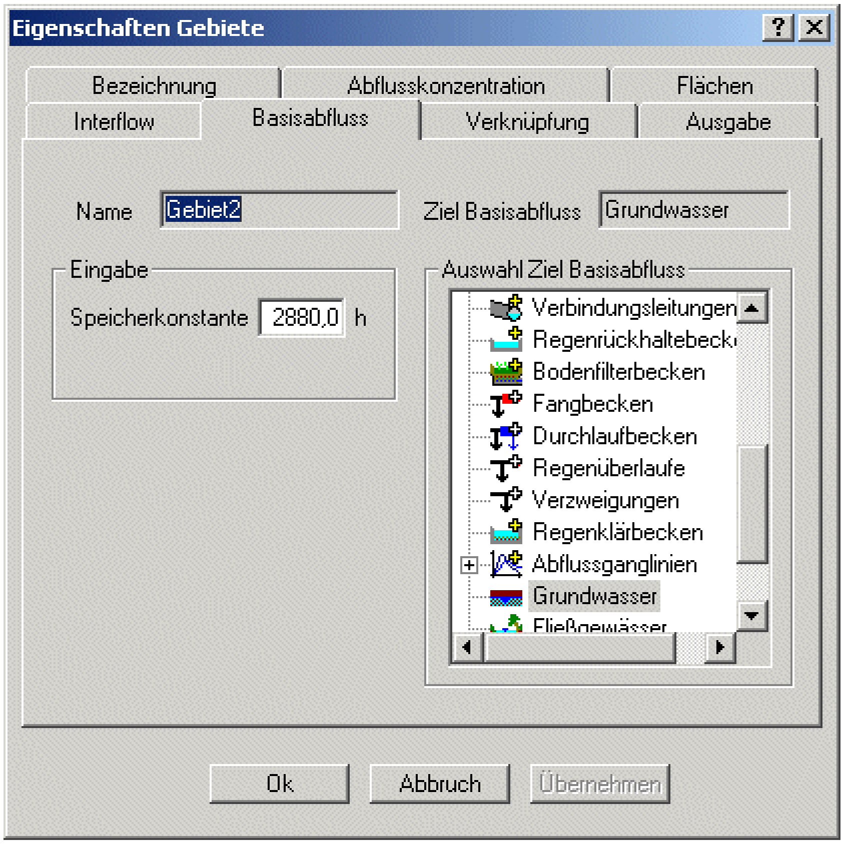
- In the section labled "*No. of Storages*" you enter the number of storages that influence the runoff duration and therefore the "Runoff Concentration".
- By clicking on the checkbox you can select whether you want to directly indicate the *Storage Constant* for the storage in min. or whether it should be calculated from the flowtime in the sewer network and the flowtime on the surface.

In the ***"Time-Surface Function"*** section you are able to edit this.

1.3.8.2 Catchment Properties: Interflow Tab



1.3.8.3 Catchment Properties: Base Runoff



1.3.8.4 Überregnung

Im Eigenschaftsdialogfeld “Überregnung” können Sie dem Gebiet mehrere Regenschreiber zuordnen.

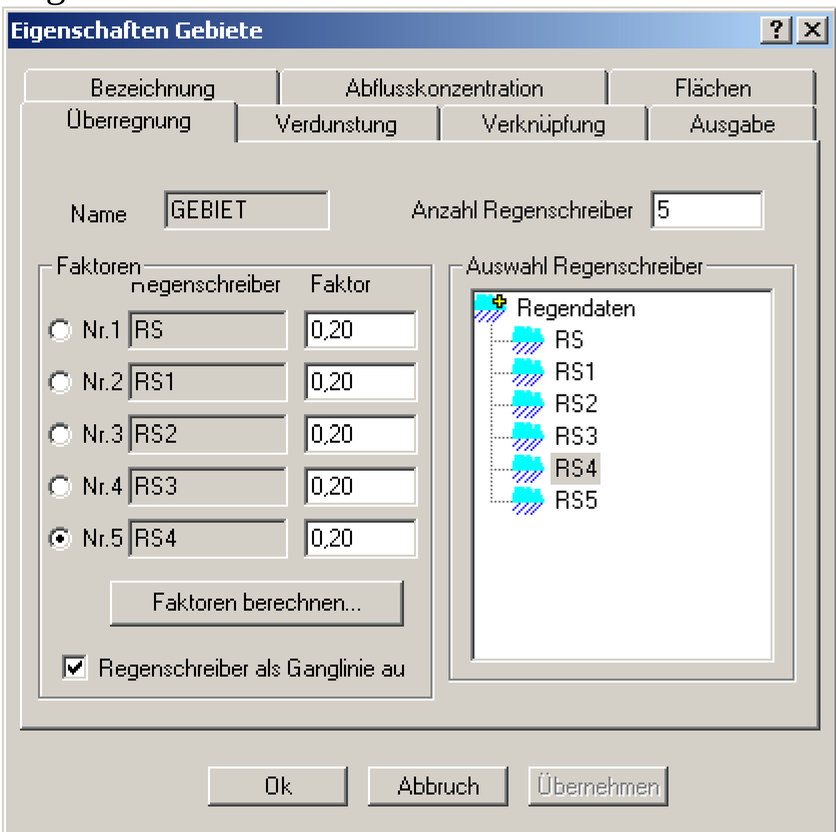
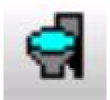


Abbildung 1-91: Festlegung der Regenschreiber für das Gebietselement Im rechten oberen Feld können Sie die Anzahl der vorhandenen Regenschreiber (maximal 5) angeben. Tragen Sie die entsprechende Zahl ein und klicken Sie auf Einstellung "Übernehmen".

Je nach Anzahl der Regenschreiber werden im Bereich Faktoren die jeweiligen Nummern freigeschaltet. Über das Auswahlbutton vor der Regenschreibernummer können Sie festlegen welchen Regenschreiber Sie bearbeiten wollen. Sie können dabei jedem Element einen vordefinierten Regenschreiber aus dem linken Auswahlbereich zuordnen. Die Faktoren mit denen die Regenschreiber in die Berechnung einfließen, können Sie über das Button "Faktoren berechnen..." automatisch bestimmen lasssen.

1.3.8.5 Evaporation

1.3.9 Trockenwetter

 Mit der hier abgebildeten Symbolschaltfläche und über das Kontextmenü der rechten Maustaste können neue Trockenwetterobjekte erzeugt werden.
Die Eingabe der Bezeichnung, des Standortes und eventueller Kommentare erfolgt im Dialogfenster „Bezeichnung“.
Im Eigenschaftsdialog "Trockenwetteranfall" legen Sie die Eingangsdaten für die Berechnung des Trockenwetterabflusses fest.
Sie können hier auswählen, ob die Einwohnergleichwerte (EGW) aus der Einwohnerdichte des Gebietes errechnet werden soll. Hierzu müssen Sie die Anzahl "EGW/ha" angegeben. Ist die Fläche bekannt, geben Sie diese in das Feld "Bezugsfläche" ein.
Durch Anklicken des Häkchens legen Sie fest, dass der Wasserverbrauch (Qs24) aus der Angabe Wasserverbrauch in l/(EGW*d) und der errechneten Anzahl der Einwohner ermittelt wird. Falls Sie die Anzahl der EGW genau wissen, kann die automatische Berechnung der EGW aus der Dichte abgewählt und die Zahl in das nun aktive Feld "EGW" eintragen werden.

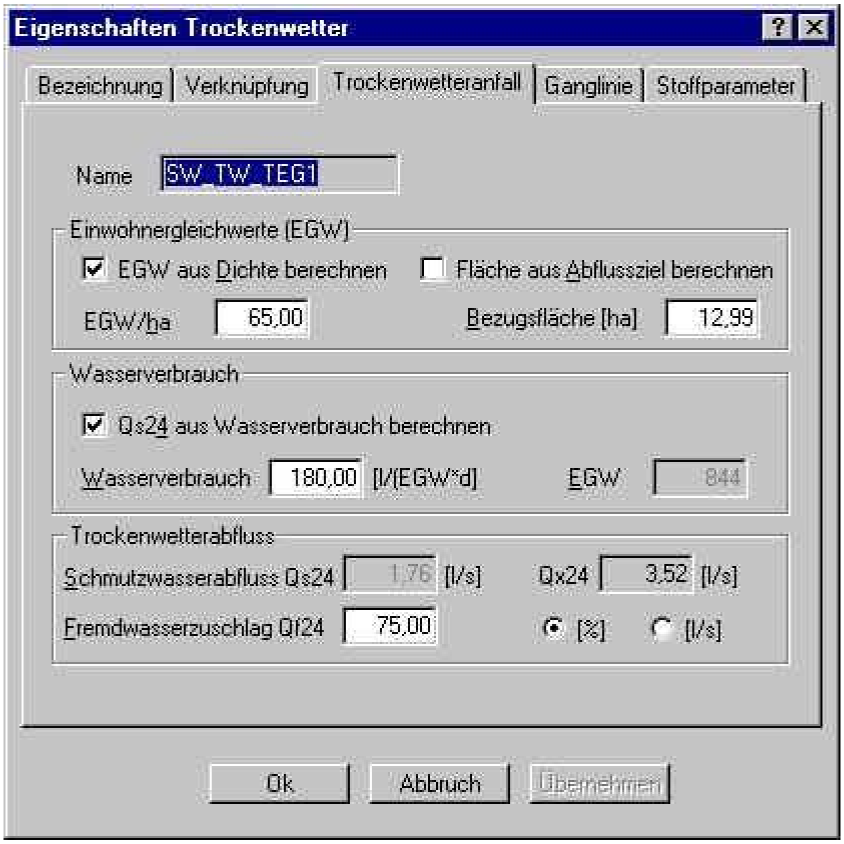


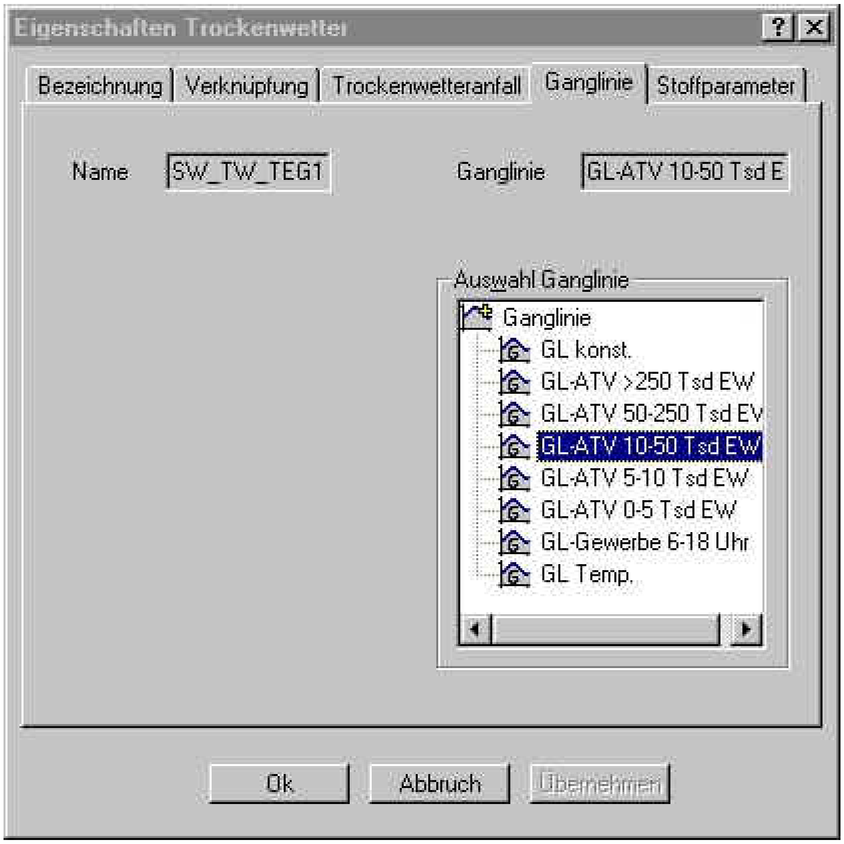
Abbildung 3-24: Erfassung des Trockenwetteranfalls

Im Bereich „Trockenwetterabfluss“ werden der Schmutzwasserabfluss Qs24 (mittlerer Abfluss) und Qx24 (Spitzenabfluss) automatisch errechnet. Der Fremdwasserzuschlag kann wahlweise in % des Schmutzwasserabflusses Qs24 oder explizit in l/s angegeben werden.

In der Karteikarte „Ganglinie“ wählen Sie im Feld "Auswahl Ganglinie" für den Trockenwetteranfall eine Ganglinie aus. Diese orientiert sich an der Größe der Kommune oder anderen Faktoren. Es können aber auch eigens erstellte Ganglinien ausgewählt werden.

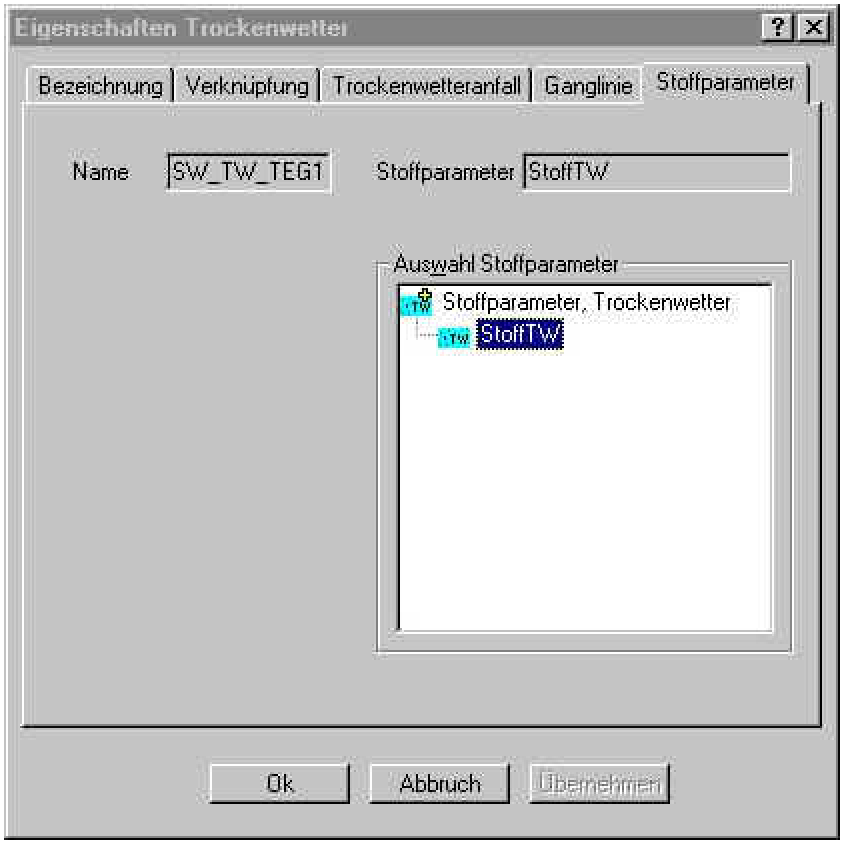
Im Feld "Auswahl Stoffparameter", im Dialogfeld „Stoffparameter“, wählen Sie für den Trockenwetteranfall den dazugehörigen Stoffparametersatz der Trockenwetterverschmutzung.

1.3.9.1 Dry Weather Properties: Hydrograph Tab



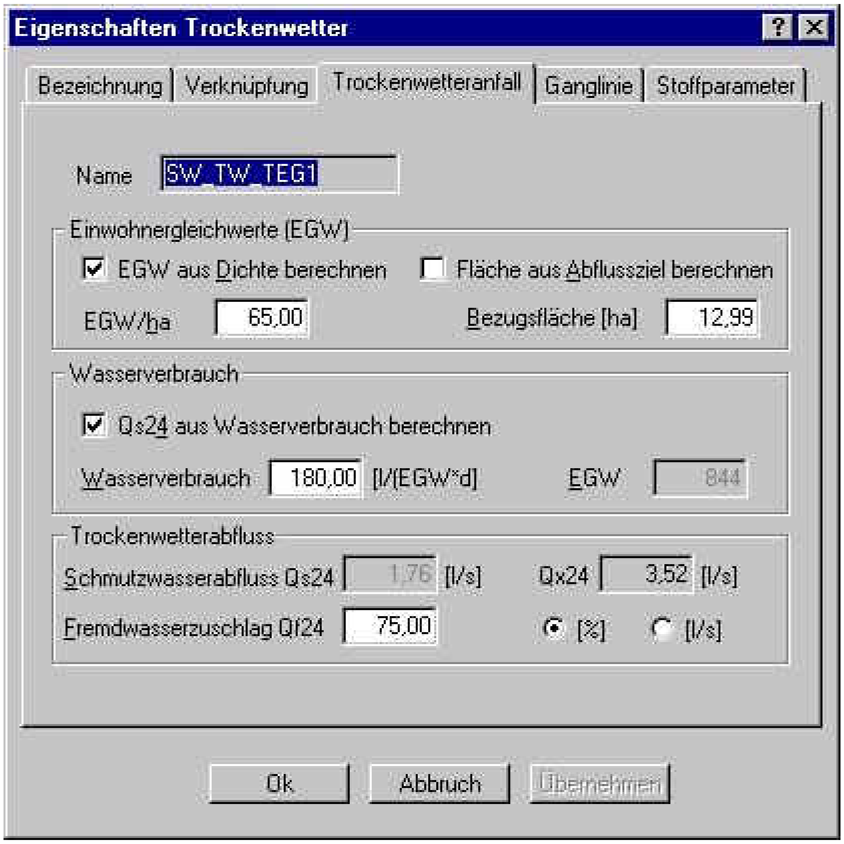
In the section titled "Choose Hydrograph" you select a hydrograph for a dry weather flow. This orientates itself to the size of the community or other factors. You can also select a specially created hydrograph.

1.3.9.2 Dry Weather Properties: Substance Parameters Tab



In the section titled "Choose substance parameters" you select the appropriate set of substance parameters for dry weather pollution for dry weather flow.

1.3.9.3 Dry Weather Properties: Dry Weather Flow Tab



In the "Dry weather flow" tab you set the input data for the calculation of the dry weather runoff.

Population Equivalent (PE)

You can select whether the PE number should be determined from the catchment's population density. For this you must indicate the number of inhabitants per ha. If the area is known, type this in the "area" input field.

Water Consumption

By activating the checkbox in the "Consumption" section, you indicate that water consumption (Qs24) is determined from the indicated water consumption l/(ihn*day) and the calculated number of inhabitants. In case you know the population equivalent exactly, you can deselect the automatic calculation of the PE from density and enter the number in the now-active field "Inh".

Dry Weather Runoff
The dry weather flow (average runoff) und Qx24 (Peak runoff) are calculated automatically.
The sewer infiltration water can alternatively be indicated as a percent of the dry weather flow or explicitly in l/s.

1.3.10 Entwässerungselemente

1.3.10.1 Dezentrale Regenwasserelemente

Zu jedem Entwässerungselement existiert mindestens ein Zufluss und ein Abfluss. Die Zuordnung der Zuflüsse erfolgt entweder direkt bei der Eingabe der Flächen oder der Zufluss entsteht durch Abfluss bzw. Überlauf eines anderen Entwässerungselementes. Die Zuordnung der Abflüsse erfolgt im Dialogfenster, je nach Entwässerungselement inden Karteikarten „Drossel“, „Versickerung“ und „Verknüpfung“ bzw. durch Verdunstungaus dem Bodenspeicher. Für die Entwässerungselemente „Zisterne“, „Mulde“, „Rigole“ und „Regenrückhaltebecken“ kann in der Karteikarte „Überlauf“ ein Überlaufziel als zusätzlicher Abfluss eingegeben werden.
Die Karteikarte „Flächen“ im Eigenschaftsdialog der Entwässerungselementedient nur zur Kontrolle der an das Objekt angeschlossenen Flächen.

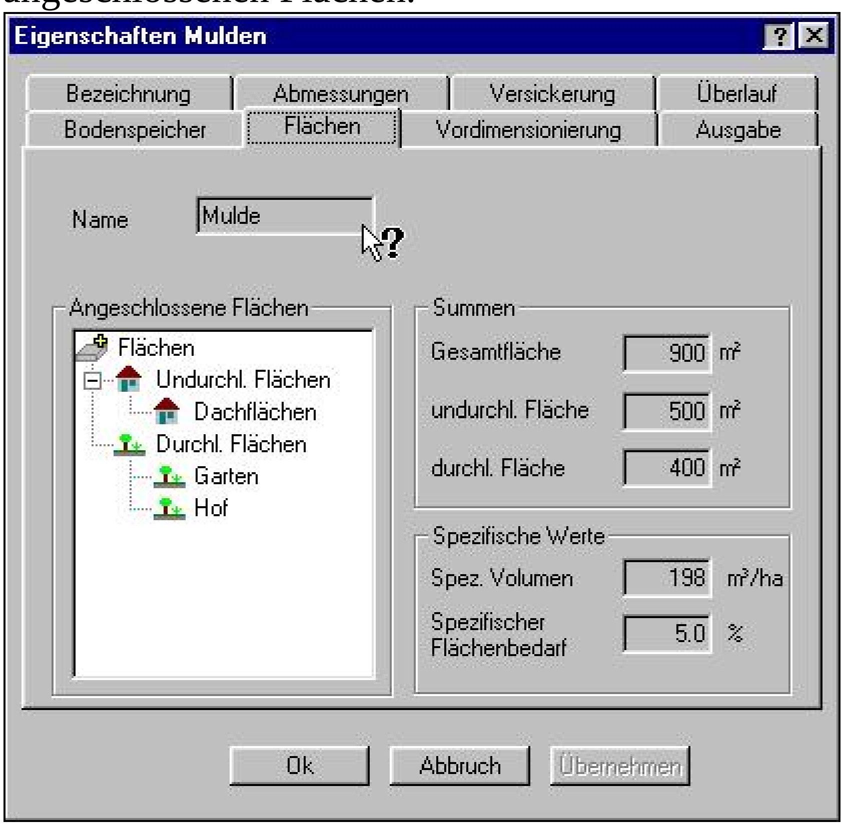


Abbildung 3-25: Karteikarte „Flächen“ im Dialogfenster „Eigenschaften Mulden“

Die Karteikarte „Ausgabe“ im Eigenschaftsdialog der Entwässerungselemente dient der Steuerung der Ergebnisausgabe. Im Bereich „Ausgabeparameter“ kann die Anzahl der maßgebenden Einstauereignisse angegeben werden. Die Anzahl der Einstauereignisse ist

Grundlage für die Auswertestatistik (siehe Abschnitt 5.3). Die Aktivierung des Kontrollkästchens “Ausgabe der Einzelereignisse” sorgt für die Ausgabe aller Einzelergebnisse im Ergebnisbericht.
Im Bereich Wasserstandsganglinie kann der Dateiname für die Ausgabe der berechneten Wasserstände angegeben werden. Der Ausgabezeitraum kann durch die Eingabe in den Feldern „Beginn“ und „Ende“ eingeschränkt werden. Durch die Angabe eines Schwellenwertes kann erreicht werden, dass die Wasserstände nur ab diesem Wert ausgegeben werden, wodurch sich der Umfang der Ausgabe oftmals erheblich reduzieren lässt.

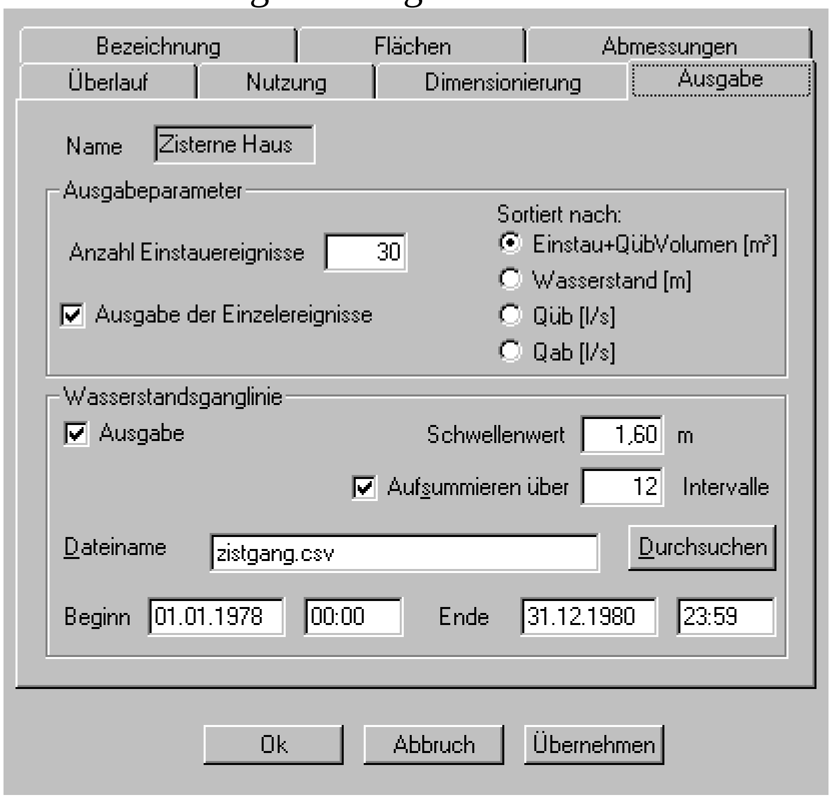


Abbildung 3-26: Karteikarte „Ausgabe“ im Dialogfenster „Eigenschaften Mulden“

1.3.10.1.1 Cisterns

Click this symbol to create a new cistern. This may also be achieved by clicking the menu option "Add new" in the "System Elements" pulldown menu or by choosing "Add new" from the context menu when "Cisterns" in the element tree is clicked with the right mouse button.

After input of the designation and location of the cistern, the geometry of the cistern must be entered in the "Dimensions" tab.

Figure 3-27: Entering the geometric data for a cistern

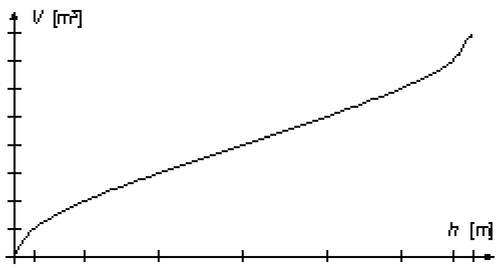
If the cistern is block shaped, specifying its length, width and depth is sufficient for the automatic calculation of the necessary volume characteristic curve. For other geometrical forms (e.g. cylinders, cones or spheres) a specific characteristic curve needs to be calculated and entered as input.

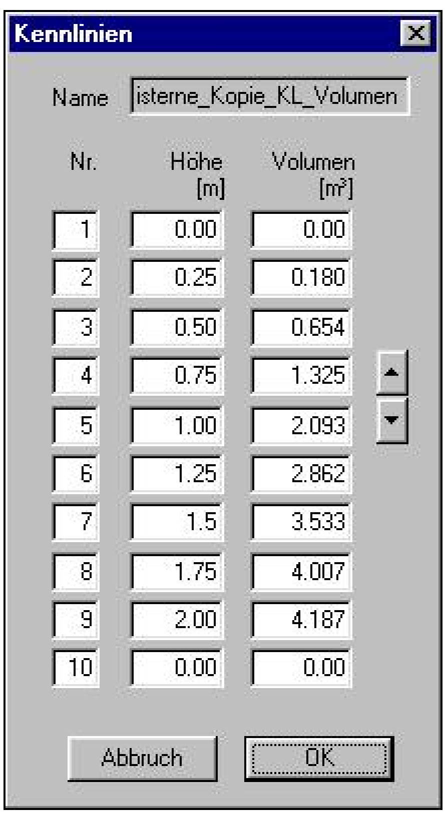
The characetistic curve of a spherical cistern with a diameter of 2 m is given as an example. After deactivating the automatic control switch and clicking the button "Volume = f(Depth)", the values are entered into the adjacent table.

The values can be found using:

$$V = \frac{\pi}{3} \cdot h^2 \cdot (3 \cdot r - h)$$

for both halves of the sphere.





Kennlinien

Name: isterne_Kopie_KL_Volumen

Nr.	Höhe [m]	Volumen [m³]
1	0.00	0.00
2	0.25	0.180
3	0.50	0.654
4	0.75	1.325
5	1.00	2.093
6	1.25	2.862
7	1.5	3.533
8	1.75	4.007
9	2.00	4.187
10	0.00	0.00

Abbruch OK

Figure 3-28: Volume characteristic curve for a sphere with a diameter of 2 metres

In the "Overflow" tab, specifications about the overflow height and overflow capacity are made. The latter can be determined by the programme automatically. Specifying an overflow destination may only be feasible once all drainage elements have been defined. If necessary, an overflow characteristic curve may be defined similar to entering values describing a volume characteristic curve.

The inflow to the cistern can be checked in the "Surfaces" tab; the daily withdrawal of water is entered in the "Use" tab. The automatic calculation of the withdrawal rate is based on the annual rainwater needs and activated using the check boxes as shown in Figure 3-29. Bear in mind that withdrawal for watering gardens and lawns only occurs in the months from May to September.

Figure 3-29: Entering water withdrawal for utilising a cistern

By clicking the "Pre-dimensioning" button in the "Dimensioning" tab, a check can be made whether the geometry of the cistern (dimensions and overflow height) is sufficient, in regard to the yearly height of precipitation and discharge coefficients, to provide the required water volume. When using cube/block shaped cisterns, their dimensions (length, width or depth) can be fitted to the necessary storage volume by clicking the "Fit" button.

Cistern Properties: Dimensions Tab

In the properties dialog for cisterns you'll find the "Dimensions" tab.

Input

In the "Input" section you can enter the element's length

width and

depth

All entries should be made in m.

Volume Characteristics

In the "Volume Characteristics" section, the cistern's volume characteristic curve is defined. The volume curve depicts the cistern's storage volume (in m^3) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise you can adjust the curve manually.
An initial volume can be given as a percentage of total storage volume.
Results
In the "Results" section, the values for bottom area and storage volume calculated automatically from the input are shown.

Cistern Properties: Dimensioning Tab

In the properties dialog for cisterns you'll find the "Dimensioning" tab.

Input
In the "Initial Parameters" section you can enter average yearly precipitation in mm. Additionally you can enter the average runoff coefficient for the connected surface.

Computation

In the "Computation" section, a pre-dimensioning of the element is undertaken. In addition to the actually available volume (in m^3) shown in the "existing volume" field, you can see the required volume (in m^3) shown in the "required volume" field. If the available volume is not enough, the output is shown in red, otherwise in green.

Pre-dimensioning occurs by comparing the projected water needs, which are calculated from the entered usage, to the rainwater available, which in turn is determined from the annual precipitation falling on connected surface.

Fit Dimensions

In the "Fit Dimensions" section you have the possibility to adjust the element's volume to the required volume. The required volume is determined from predimensioning or from long-term simulation, if this has been completed.

Choose whether you want to adjust length, width or depth. In the "ex. value" field, the current value is shown. In the "re. value" field, the newly calculated value is shown. This is the value required in oder to provide enough storage volume. If the existing value is not enough, the output is shown in red, otherwise in green.

By clicking on the "Fit" button, the adjustment is made; i.e. the current value is saved.

If the rain yield is higher than the rainwater needs by more than 20%, a smaller storage can be planned since the storage will be filled by frequent precipitation more quickly. It isn't necessary to store large amounts of water for a long period of time.

Cistern Properties: Use Tab

In the properties dialog for cisterns you'll find the "Use" tab.
In the "Use" section you set the type and average amount of withdrawn rainwater. One part of this is the daily necessary amount of water for flushing toilets, either regular or economy (you must choose one or the other). Other possible components include uses such as for washing machines or for watering lawns and gardens.

For uses such as for washing machines and flushing toilets, it is necessary to enter the number of people in the household. For watering gardens, the total surface area of the garden must be given (in m^2).

Default Values are:
Regular toilet 14 m^3/(Pers.*a)
Economy toilet 8 m^3/(Pers.*a)
Washing machine 6 m^3/(Pers.*a)

Lawn/Garden 6 $m^3/(100m^2*a)$

Required Rainwater

In the "Required rainwater" field, the annual required amount is shown (in m^3/a).

Withdrawal

In the "Withdrawal" section, the average daily withdrawal is calculated automatically. You can also manually enter a daily withdrawal rate (in l/d) by deactivating the "autom." checkbox.

Computation

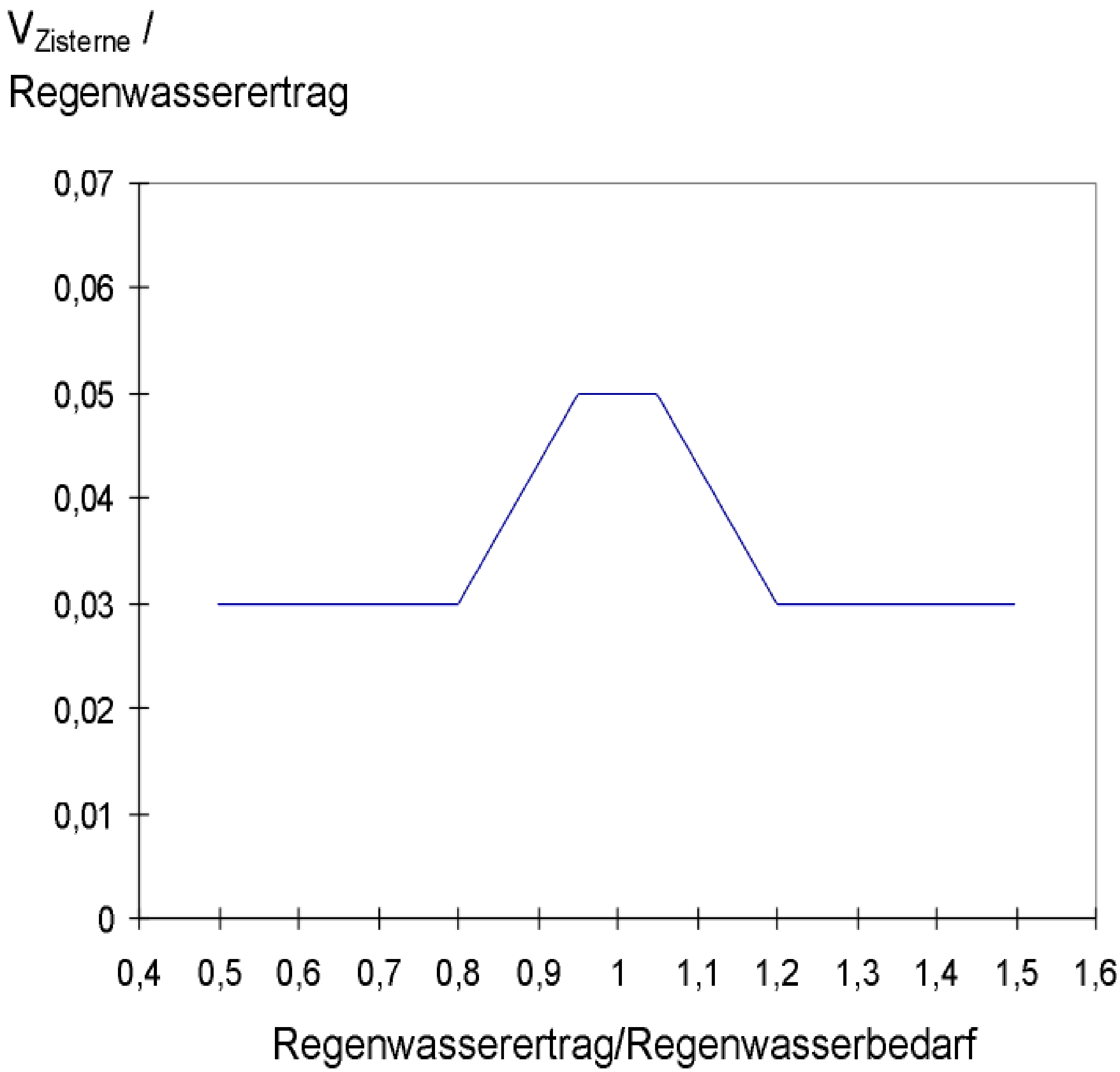
The rainwater yield (RE) is determiend from the connected roof surface area and the yearly hight of precipitation.

It is calculated by the following equation: *RE = Roof (m² surface area) * Runoff Coefficient * Hight of Precipitation (mm) * 0,001*

The runoff coefficient depends on the type of roof and can be approximated as 0.75 for steep slanted roofs and 0.6 for flat roofs (WILHELM et al.).

Using the ratio between rainwater yield (RE) and required rainwater (RB), the required storage size of the cistern is determined by means of statistically calculated average values as a portion of the rainwater yield. The average values are based on the recognition that the availability of rainwater with a large storage only increases insignificantly starting at a certain size. With the way this method is designed, an average degree of coverage for rainwater usage of 90% is attained.

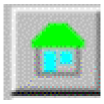
The figure below and the following equations describe the process of calculating the storage requirements.



When...., then........
RE/RB < 0.5 Warning: rainwater yield is too small 0.5 <= RE/RB < 0.8 VCistern = 0.03*RE
0.8 <= RE/RB < 0.95 interpolate VCistern 0.95 <= RE/RB < 1.05 VCistern = 0.05*RE
1.05 <= RE/RB < 1.20 interpolate VCistern 1.2 <= RE/RB VCistern = 0.03*RE

The following recognitions are to be inferred: With a small rainwater yield, a smaller storage is required than with a higher rainwater yield. If the rainwater yield is less than the required rainwater by 20%, a storage larger than 3% of the rainwater yield would never be completely used up.

1.3.10.1.2 Green Roofs

 With this button, with the context menu (right mouseclick) or the menu item "Add new" in the "System Elements" pulldown menu, new green roofs can be added.
The green roof has been implemented into the programme as a new element. At this point it should be noted that methods of construction for green rooofs are very different and that no universally valid parameter sets can be given in the programme. We would like to ask you to calibrate the parameters through measurements. Otherwise the results are not meaningful.

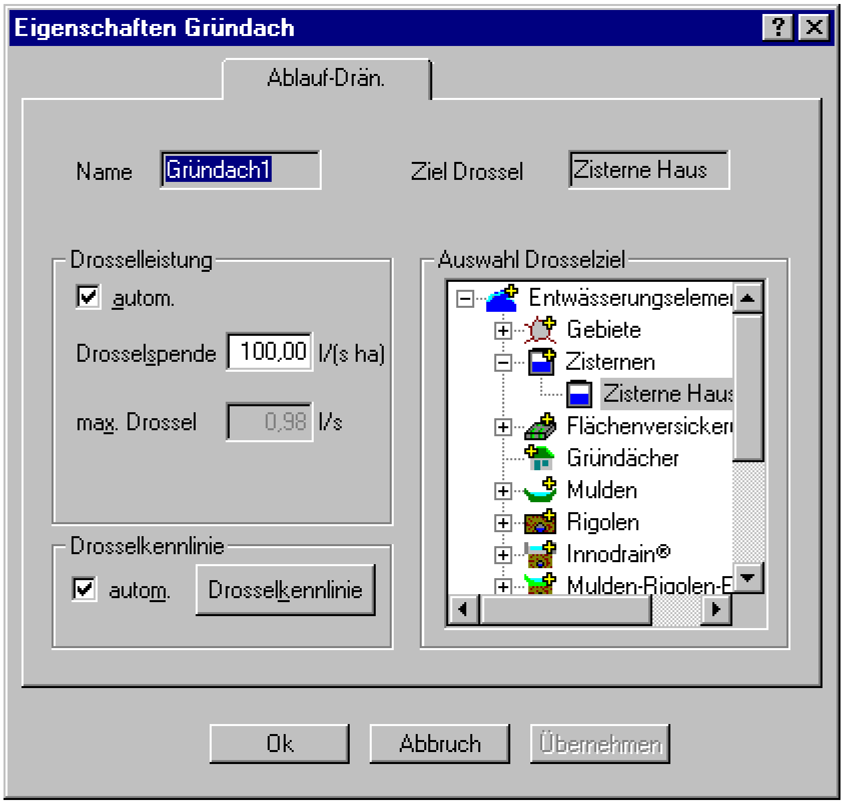
After inputting the designation and location of the green roof, its geometry must be entered in the "Vegetation" tab. This vegetation layer is modelled as ground storage. If the shape of the green roof deviates from the standard (cube), a volume characteristic curve should be entered as with the cisterns in section 1.3.10.1.1.
In the "Infiltration" tab in the dialog window "Green Roof Properties" the data for the infiltration from the vegetation layer is entered. The definitive Kf-value for the infiltration can be inputted directly or determined by selecting the soil type. The infiltration destination is generally the underlying drainage layer. If necessary, a separate infiltration surface curve can be plotted alone the lines of the volume characteristic curve.

Figure 3-30: Entering the vegetation layer for a green roof

Specifications to the overflow hight and overflow capacity can be made in the "OVFL Drain" tab. The overflow capacity is normally determined by the programme automatically. It is required to plot a separate overflow curve along the lines of the volume characteristic curve. Specifying an overflow destination can also be done here.

The evaporation loss from the swale is determined from the specifications of the depth and pore volume of the drainage layer in the "Drainage Layer" tab. An additional inflow to the green roof can be specified in the "Surfaces" tab.

Green Roofs: Drain Tab



In the green roof properties dialog you'll find the "Drain" tab.

Throttle Capacity

Note: The throttle capacity should be adjusted to the geometry of a roof. Since the geometries are very different, no throttle curves can be given here. They must be adjusted for each particular roof.

In the "Throttle Performance" section, you can preset an area-specific throttle intensity. The default value is 10 l/(s*ha). At the same time, the discharge capacity is automatically calculated as a function of the connected runoff-effective surface, in this case, the surface area of the roof.

If the "autom." checkbox is deactivated, you can manually define an element-specific throttle discharge capacity in the "max. throttle" field. The max. throttle capacity is reached when the trench is full. The throttle curve is calculated from this by the programme in case it is not manually entered.

Throttle Characteristic Curve

In the "Throttle Characteristics" section, the swale or trench curve is defined. The throttle curve depicts the throttle capacity (in l/s) as a function of water level h (in m).

If the "autom." checkbox is activated, the curve is automatically calculated. Otherwise you can manually set the curve.

Choose Throttle Destination

In the "Choose Throttle Destination" section you can choose any element as the destination for the throttled discharge.

Green Roofs: Drainage Layer Tab

In the "Drainage Layer" tab you define the size and thickness of the green roof.

Input In the "Input" section, the size of the drainage layer is indicated.

Surface Surface area in m².

Pore volume Given as a %

Drainage layer thickness Given in cm.

Water depth in drainage layer Given in cm.

Volume

In the "Volume" section, the maximum impound volume is set. The volume curve depicts the element's volume (in m^3) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise you can manually set the curve.
The initial volume can be indicated as a percent of the total storage volume.
Results
In the "Results" section, the calculated storage volume is indicated.

Green Roofs: Vegetation Tab

In the "Vegetation" tab you define the size and thickness of the green roof.

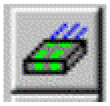
Input

In the "Input" section, the size of the green roof is given in m². Additionally, the thickness of the vegetation layer (in cm) and the useable field capacity is indicated.

Volume Characteristic Curve

In the "Volume Characteristics" section, the maximum impound volume is set. The volume curve depicts the element's volume (in m^3) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise you can manually enter the curve.
The initial volume can be indicated as a percent of total storage volume.
Infiltration
In the "Infiltration" section, the kf-value is given for the vegetation layer. From this, the infiltration curve is calculated, which can be manually altered.
Results
In the "Results" section, the calculated storage volume is given.

1.3.10.1.3 Surface Infiltration

 With this button, or via the context menu (right mouseclick), as well as via the menu item "Add new" in the "System Elements" pulldown menu, a new surface infiltration element can be added.
After inputting the designation and location of the infiltration facility, its geometry must be entered in the "Dimensions" tab. If the shape of the surface infiltration facility deviates from the standard, a volume characteristic curve should be entered as with the cisterns in section 3.11.1.
In the "Infiltration" tab in the "Surface Infiltration Properties" dialog window, the data for infiltration from the surface are entered. The decisive kf-value for the infiltration can be directly inputted or determined by selecting a soil type. Specifying an infiltration destination may only be feasible when all drainage elements have been entered. If necessary, a separate infiltration surface curve can be entered along the lines of the volume characteristic curve.
In addition to the kf-value, the permeable percentage can be specified for calculating infiltration with paved surfaces.

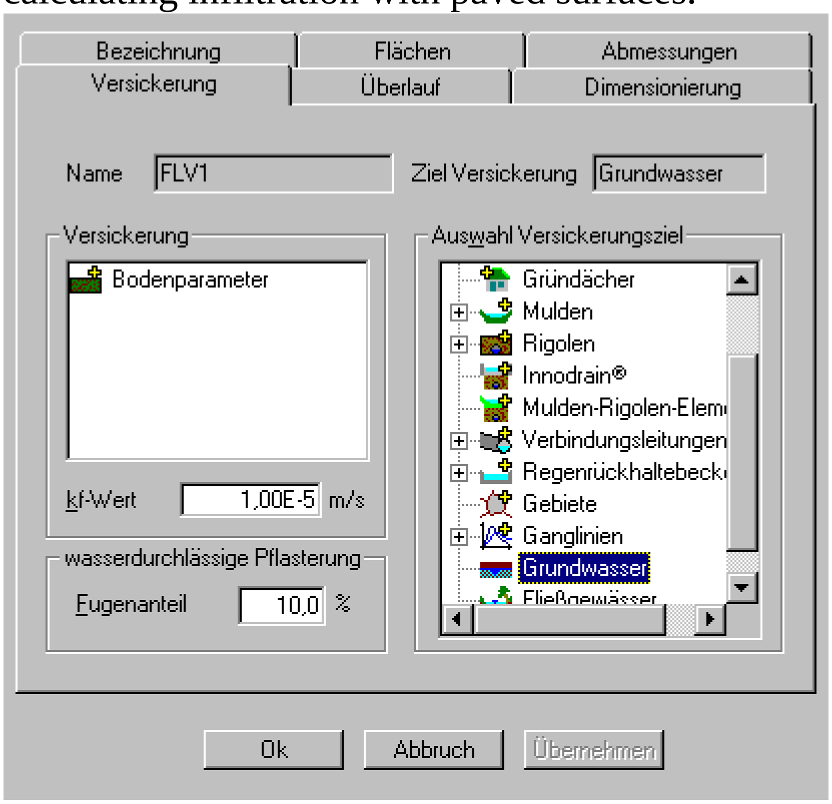


Figure 3-31: Entereing the infiltration parameters for surface infiltration

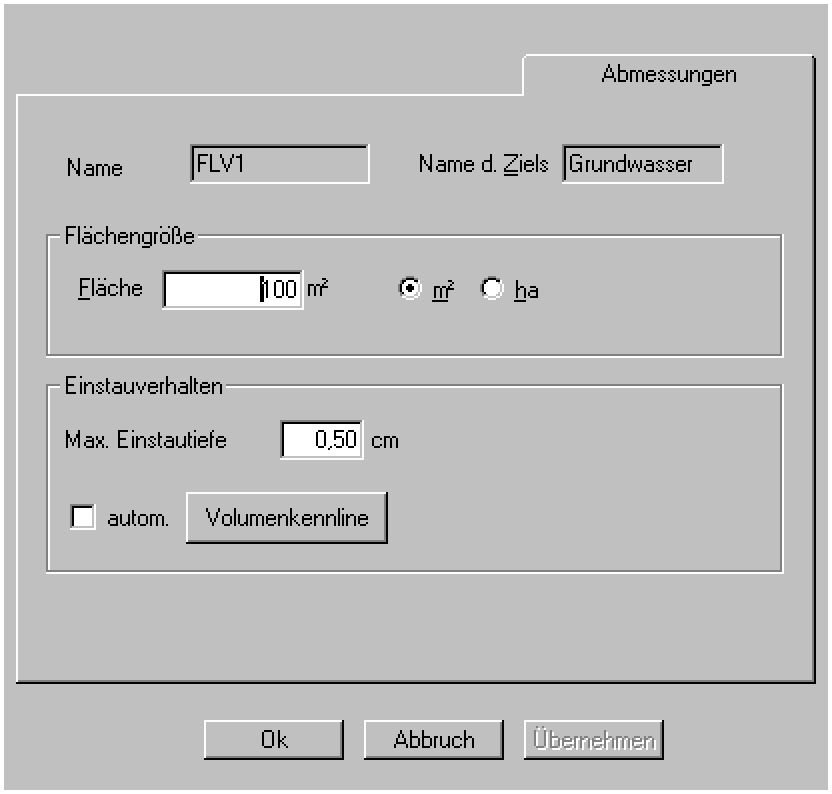
Specifications to the overflow hight and overflow capacity can be made in the "Overflow" tab. The overflow capacity is normally determined by the programme automatically. If required, a separate overflow curve can be plotted along the lines of the volume characteristic curve. Specifying the overflow destination can potentially be done later when all drainage elements have been entered.

The evaporation loss from the surface infiltration is determined in the "Ground Storage" tab through the specifications of depth and usable field capacity of the swale bed.

The inflow to the swale can be controlled in the "Surfaces" tab.

By clicking on the "Dimensioning" button in the tab of the same name, you can check whether the geometry of the surface infiltration facility (dimensions and overflow hight) is enough to provide the required storage volume considering overflow frequency, rain intensity and the assumed proportion of available to discharge-effective surfaces. When utilising surface infiltration, a facility's dimmensions can be fitted to the required storage volume by selecting one dimension (area or depth) and clicking the "Fit" button.

Surface Infiltration: Dimensions Tab

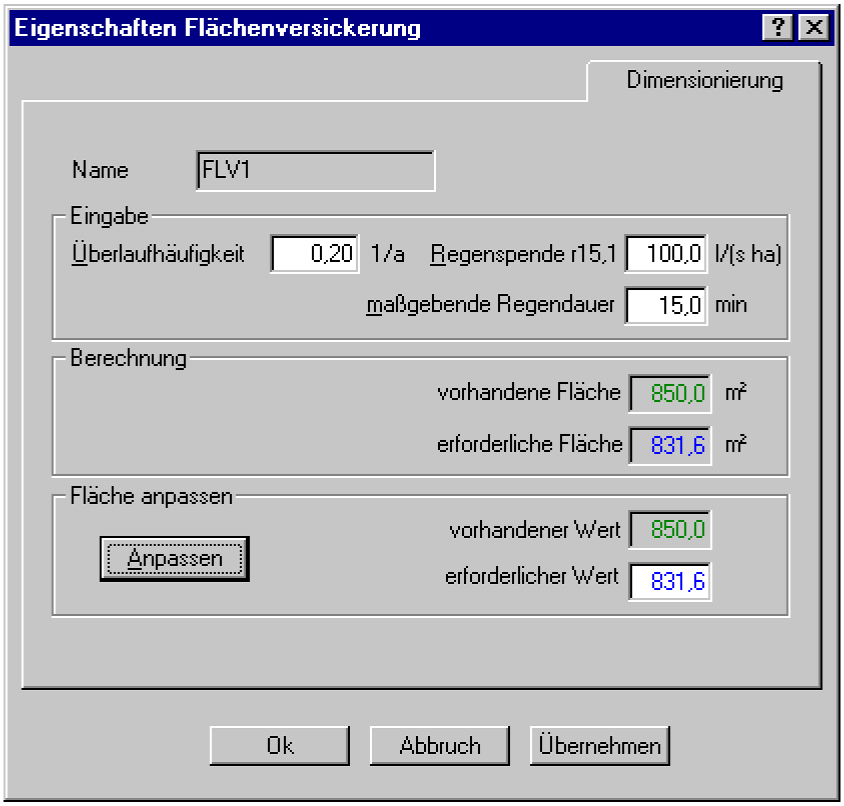


In the surface infiltration properties dialog you'll find the "Dimensions" tab.

Input
In the "Input" section you enter the surface area for the element. The entry should be given in m^2 or in ha and is based on the element's upper edge.

Impound Behaviour
In the "Impound Behaviour" section, the maximum impound depth is set. Additionally you can define the element's volume characteristic curve. The volume curve depicts the element's volume (in m^3) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise you can set the curve manually.

Surface Infiltration: Dimensioning Tab



In the surface infiltration properties dialog you'll find the "Dimensioning" tab.

Input

In the "Input" section you can input the overflow frequency per year in n/a. Additionally you can enter the rain intensity 15.1 for a 15-minute storm when n=1 in l/(s*ha) and the storm duration in minutes. Default values are n=1.0, 100 l/(s*ha) and 15 minutes.

Computation

In the "Computation" section, a "pre-dimensioning" of the element takes place automatically. In addition to the surface actually existing shown in the "existing surface" field (in mē), you can see the surface required (in mē) in the "required surface area" field. If the existing surface is enough, it is shown in green writing; if the existing surface is not enough, it is shown in red writing. If the computation cannot be completed, that is, if surface infiltration is not possible under the given specifications (kf-value, etc.), then the required surface is 0 and this is shown in red letters.

Pre-dimensioning occurs in accordance with German specifications *ATV-Arbeitsblatt A138*.

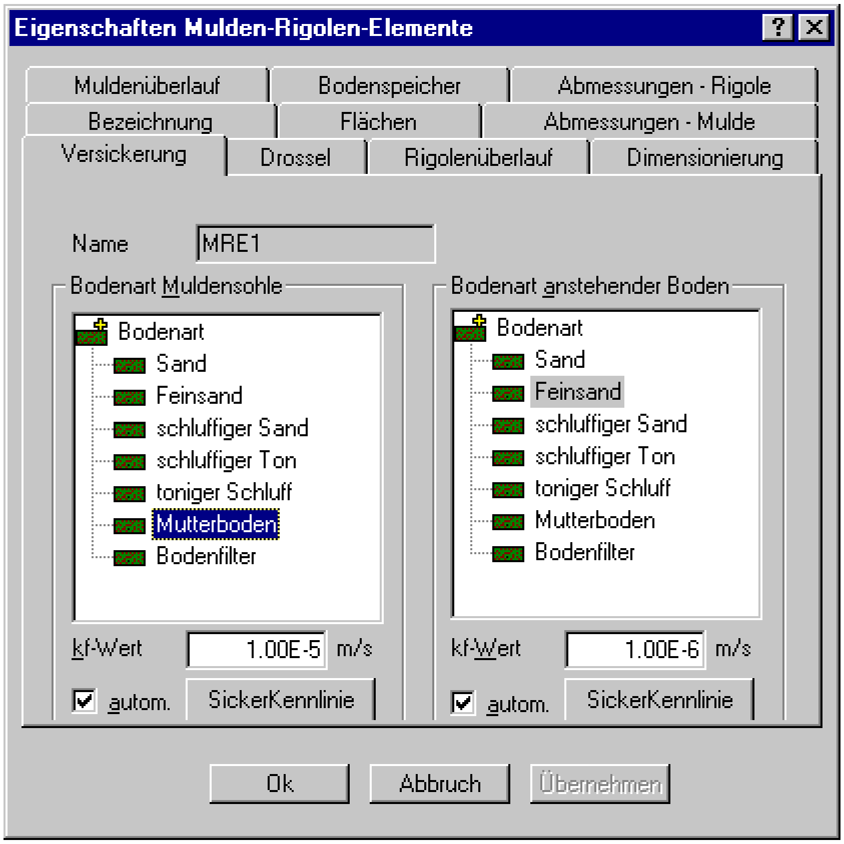
Fit Dimensions

In the "Fit Dimensions" section, you have the ability to make the element's surface area conform to the required surface area. The required surface is known from either pre-dimensioning or long-term simulation if it was carried out. If the existing surface is enough, it is shown in green lettering; if the existing surface is not enough, then in red lettering.

Choose whether you want to adjust the surface or the depth to the requirements. In the "existing value" field, the current value is indicated. In the "required value" is shown recalculated. This is the value that's required in order to allow for the required storage volume.

With a click on the "Fit" button, the adjustment occurs; i.e. the current value is saved.

Surface Infiltration: Infiltration Tab

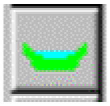


In the surface infiltration properties dialog you'll find the "Infiltration" tab.

Infiltration
In the "Infiltration" section you can indicate the type of soil for the infiltration. For the swale bottom, this is generally the topsoil (swale bed under the swale). For the surrounding soil, fine sand is selected as a default. The *Kf-value* is applied according to the chosen type of soil or can be manually entered (in m/s, scientific notation is possible).

Infiltration Characteristic Curve
The Infiltration Curve command opens the curve dialog.

1.3.10.1.4 Swales

 Either with this button, or via the context menu (right mouseclick) or via the menu item "Add new" in the "System Elements" pulldown menu, new swales can be added.

After inputting the designation and the location of the swale, its geometry must be entered in the "Dimensions" tab. If the shape of the swale deviates from the standard (obelisk), a volume characteristic curve must be defined, as with cisterns.

In the "Infiltration" tab in the "Swale Properties" dialog window, data for infiltration loss from the swale are entered. The definitive kf-value for the infiltration can be inputted directly or determined by selecting a soil type. Specifying an infiltration destination may only be feasible when all drainage elements have been entered. If necessary, a separate infiltration characteristic curve can be entered analogous to the volume characteristic.

Figure 3-32: Entering infiltration parameters for a swale

Specifications pertaining to the overflow height and overflow capacity are given in the "Overflow" tab. Normally, the overflow capacity is determined automatically by the program. Similar to the volume characteristic curve, a separate overflow characteristic curve may be defined if necessary. Specifying an overflow destination may only be possible once all drainage elements have been defined.

The evaporation loss from the swale is determined by entering the depth and the effective field capacity of the swale bed in the "Ground Storage" tab. The inflow to the trough can be controlled in the "Surfaces" tab.

By clicking on the "Dimensioning" tag, you can check whether the geometry of the swale (dimensions and overflow height) is sufficient, in regards to the overflow frequency, rain intensity and the assumed proportion of available space to discharge-effective surface ratio, to provide the required storage volume. When using cube/block shaped swales in the shape of an obelisk, their dimensions can be fitted to the necessary storage volume by selecting one dimension (length, width or depth) and clicking the "Fit" button (see Figure 3-33).

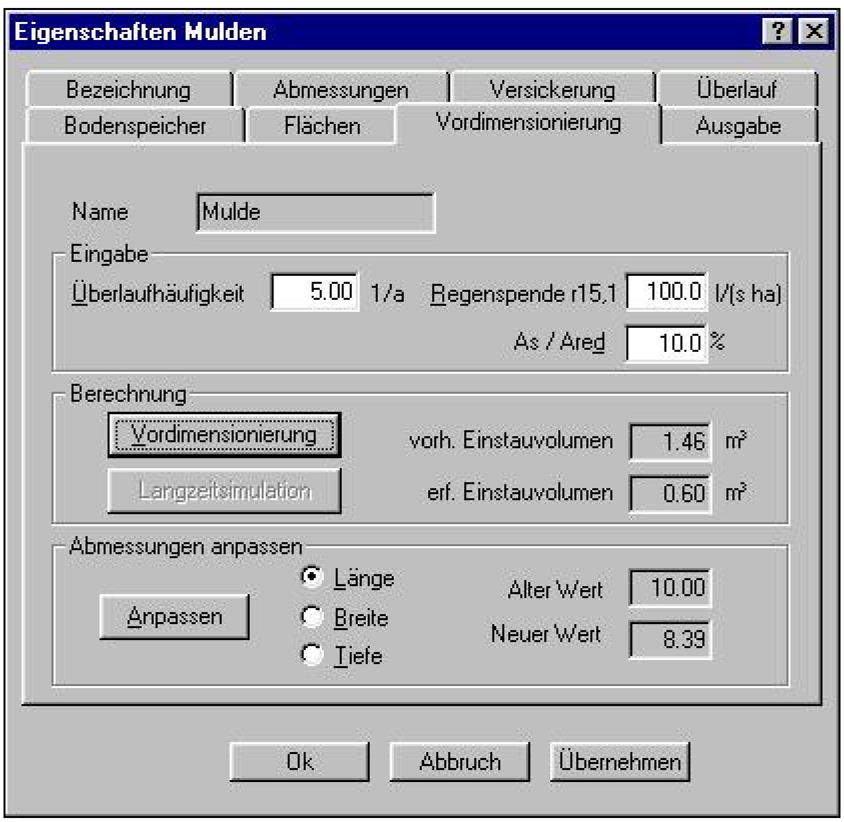
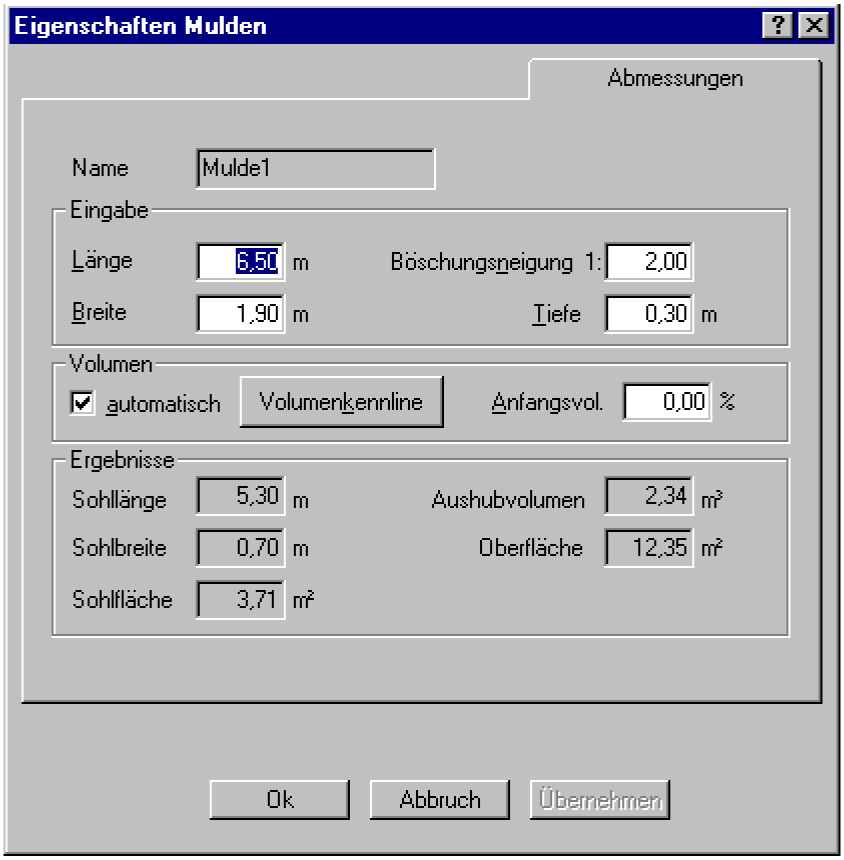


Figure 3-33: Dimensioning for a swale

Swale Properties: Dimensions Tab



In the properties dialog for swales, you'll find the "Dimensions" tab.

Input

In the "Input" section you can enter the element's *length*

width

depth

All entries are given in m and are based on the upper edge of the element.

Additionally, the embankment slope is entered (in 1:x).

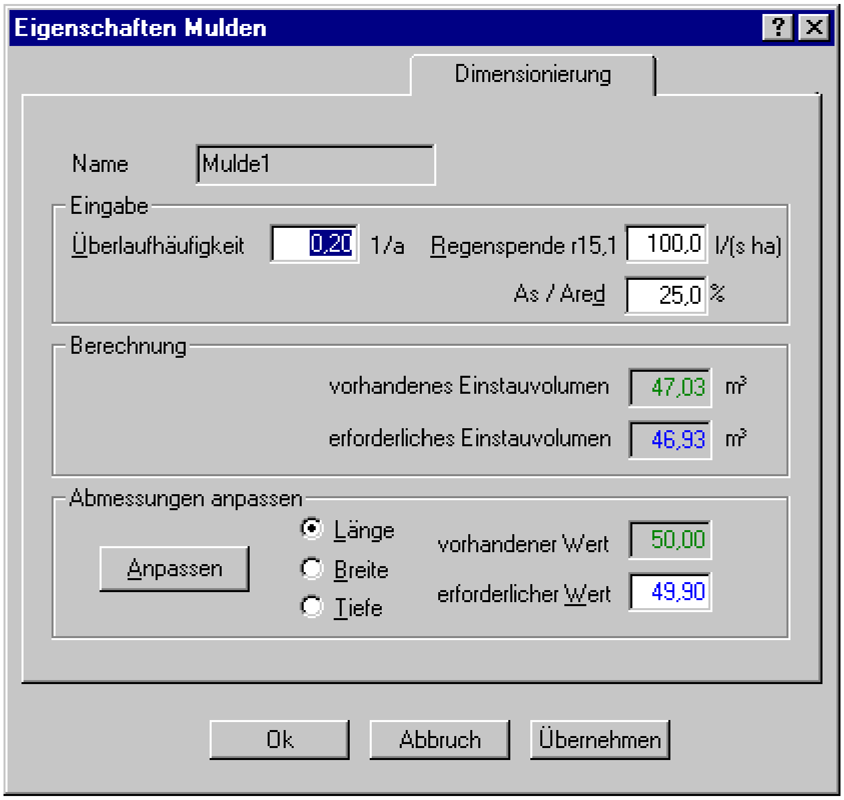
Volume Characteristic Curve

In the "Volume Characteristics" section, the element's volume curve is defined. The volume curve depicts the element's volume (in m^3) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise you can set the curve manually.
You can enter an initial volume as a percent of the total storage volume.
Results
In the "Results" section, the values calculated automatically from the inputs are shown for *bottom length*
bottom width
bottom surface area

volume and

upper surface area

Swale Properties: Dimensioning Tab



In the properties dialog for swales you'll find the "Dimensioning" tab.

Input
In the "Input" section you can enter the overflow frequency per year in n/a. Additionally, you can enter the rain intensity 15,1 for a 15-minute storm when n=1 in l/(s*ha).
Default values are n=1.0 and 100 l/(s*ha).

Computation
In the "Computation" section, the element undergoes pre-dimensioning. Additionally to the actually existing volume (in m^3) shown in the "existing impound volume" field, the required volume (in m^3) is shown in the "required impound volume" field. If the existing volume is not enough, the output is shown in red letters, otherwise in green letters.
Pre-dimensioning occurs in consideration of the German standards from ATV-Arbeitsblatt A138.

Fit Dimensions

In the "Fit Dimensions" section, you have the possibility to adjust the element's volume to the required volume. The required volume is calculated in pre-dimensioning or from long-term simulation, if this has been completed.

Select whether the length, width or depth should be adjusted. In the "Existing value" field, the current value is given. In the "Required value" vield, the newly calculated value is shown. This is the value that is required to provide the required storage volume. If the existing value is not enough, the output is shown in red lettering, otherwise in green lettering.

By clicking on the "Fit" button, the adjustment is undertaken; i.e. the current value is saved.

1.3.10.1.5 Trenches

New trenches can be created with the help of this toolbar button, using the menu option "Add new" in the "System Elements" pulldown menu, or using the context menu (right mouseclick) when "Trenches" in the element tree is selected.
In the "Trench Properties" dialog window, the designation and location of the trench are entered first, and the geometry is inputted in the "Dimensions" tab.

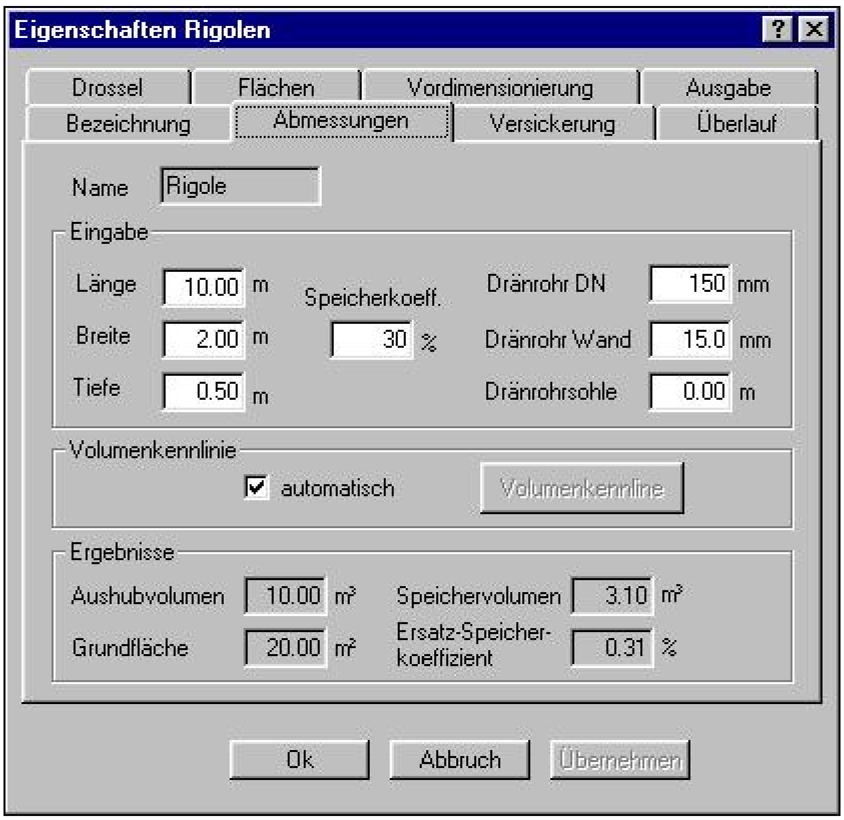


Figure 3-34: Dialog for entering the dimensions of the trench and drainpipe

The storage coefficient is the fraction of the effective storage volume of the trench, which depends on the trench filler material (see *storage coefficient* in glossary of Section 6-1 for examples). The dimensions of the drainage pipe (diameter and wall thickness) are used by the program internally to calculate the equivalent storage coefficient (consideration given to both the volume between the filler material and the volume of the drainage pipe). This receives particular relevance when, for example, the trench drainage pipe is a concrete infiltration channel. The position of the drainage pipe

(pipe bottom) determines the impoundment of the trench. The value 0.00 m corresponds to a position on the trench bottom. The infiltration and discharge behavior of the trench can be changed by modification of the pipe position.

The infiltration losses from the trench are specified in the "Infiltration" tab. As with troughs, the kf-value relevant for the infiltration can be inputted directly (see Section 3-1) or be determined by selecting a soil type. Specifying an infiltration destination may only be feasible once all drainage elements have been entered. If required, a separate infiltration area characteristic curve may be defined, which describes the infiltration area as a function of the water level.

Specification to overflow height and overflow capacity is given in the "Overflow" tab. If necessary, a separate overflow characteristic may be entered. It may be possible to indicate an overflow destination only when the corresponding drainage element has been created.

The throttle discharge from the trench is entered in "Throttle" tab as an area-specific exfiltration rate, which consists of automatically calculating the discharge capacity as a function of the connected discharge-effective surface. The maximum throttle capacity is achieved during filling of the trench. This allows the throttle characteristic to be automatically calculated, unless manual input of data is preferred by the user.

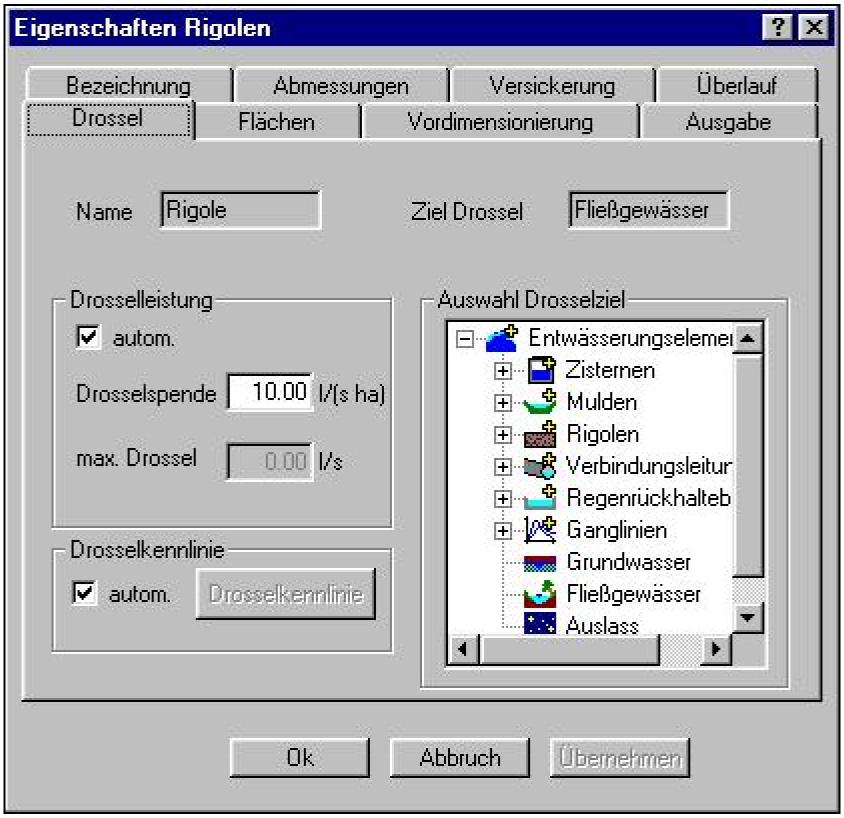


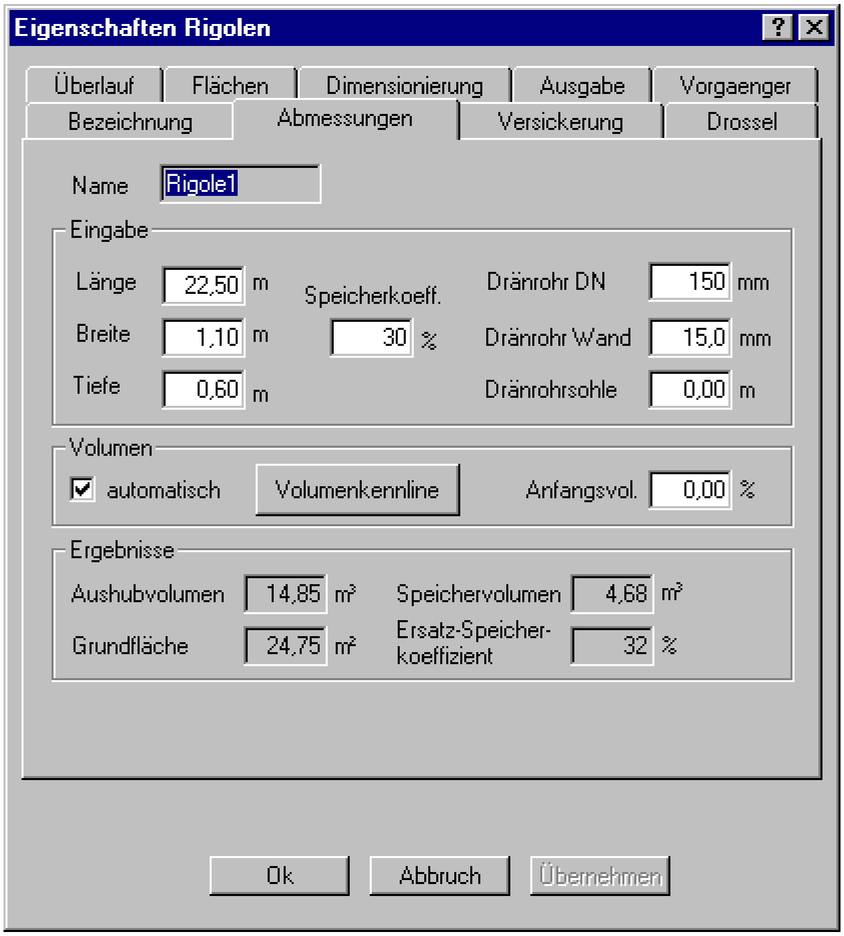
Figure 3-35: Entering throttle discharge from the trench

The total connected surfaces, which form the inflow to the trench, can be controlled in the "Surfaces" tab.

In the "Dimensioning" tab, you can check whether the geometry of the trench (dimensions, installed drainage pipe and overflow height) is sufficient to provide the necessary volume in accordance to overflow frequency and rain intensity. When using standard block shaped trenches, their dimensions can be fit to the required storage volume by selecting one dimension (length, width or depth) and clicking the "Fit" button.

The number of impounding events allowed during the simulation time period is indicated in the "Output" tab. This value determines the range of the report output and forms the basis for the statistical analysis. Activating the check box allows output of all single events in the report.

Trench Properties: Dimensions



In the trench properties dialog, you'll find the Dimensions Tab.

Input

In the "Input" section you can input the element's *length*,

width, *and*

depth

All inputs are made in metres. Additionally, the storage coefficient (in %) of the trench filler material is indicated.

The storage coefficient (%) reflects the portion of effective storage volume in the trench body, which depends on the trench filling material. It includes the spaces between the material particles and perhaps also the available porosity of the particles.

Values for storage coefficients can be taken as utilisable porosity (Vol-%) of the soil:

Medium gravel 14 - 24 Vol-%

Fine gravel 15 - 25 Vol-%
Gravelly sand 16 - 28 Vol-%
Coarse sand 15 - 30 Vol-%
Medium sand 12 - 25 Vol-%
Fine sand 10 - 20 Vol-%
Clay < 5 Vol-%

Materials that are made with a defined particle distribution have higher storage coefficients if they exhibit a uniform particle distribution curve (u < 5). According to SCHULTZE/MUHS 1967, the following values can be assumed for the porous portion:

Coarse gravel 30 - 38 Vol-%
gravelly sand (U>10) 25 - 40 Vol-%
Sand (U<5) 36 - 43 Vol-%

Drainpipe DN

With pipe trenches, a substitute storage coefficient is formed and thus the actual storage volume is determined. In the "Drainpipe DN" field, the drainpipe diameter (DN mm) is input for the drainage pipe planned for the trench. The selected diameter is used in computing the trench's maximum overflow capacity and is set automatically when defining the trench network for the arrangement of pipes downstream.

Default drainpipe diameter = 150 (mm)

Drainpipe Wall

The drainage pipe wall thickness (mm) is used along with the drainpipe diameter in the programme's computationt to determine the substitute storage coeffeicients. This option is relevent when, for example, a concrete drop-pipe is located in the trench.

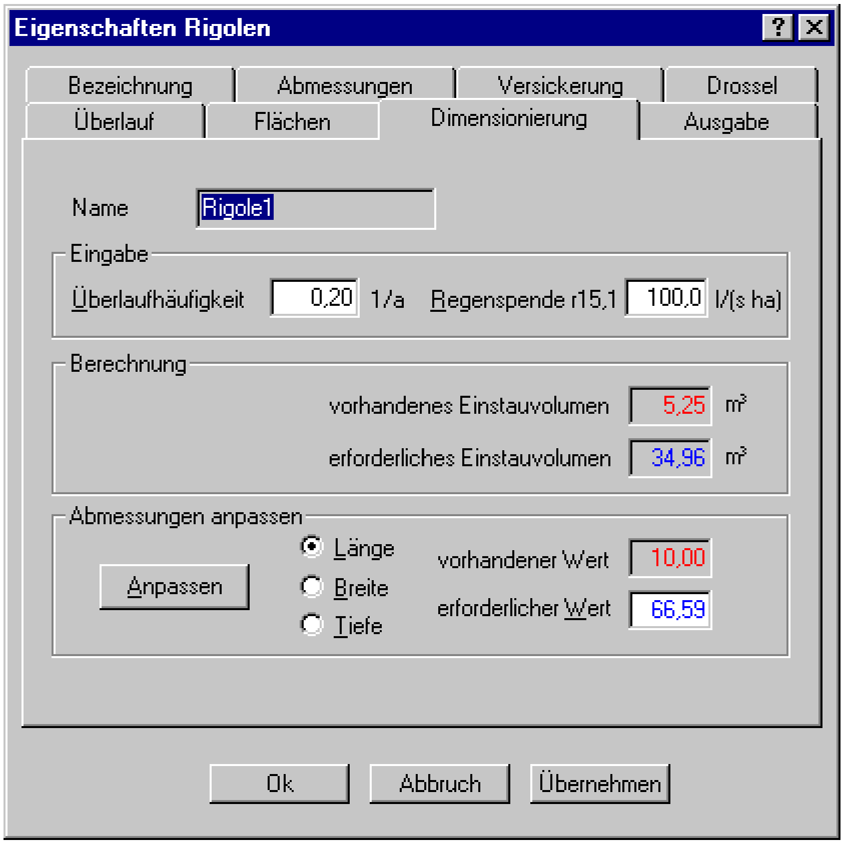
Default drainpipe wall thickness = 1,5 (mm) *Drainpipe Bottom*

The position of the drainpipe (drainpipe bottom) determines the impoundage in the trench. A location of 0 corresponds to the position of the trench bottom. By changing the position, the trench's infiltration and discharge behaviour can be changed.

Volume Characteristic Curve

In the "Volume Characteristics" section, the trench's volume characteristic curve is defined. The volume curve depicts the trench's actual storage volume (in m³) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise, you can set the curve manually.
An initial volume at the beginning of simulation can be input as a percentage.
Results
In the "Results" section, the values calculated automatically from the inputs are shown for *Excavation volume Surface area Storage volume and Substitute storage coefficient* You should understand that the substitute storage coefficient is the ratio of storage volume incl. the storage in the drainpipe to total volume.

Trenches: Dimensioning Tab



In the properties dialog for trenches, you'll find the "Dimensioning" tab.

Input

In the "Input" section, you can input the overflow frequency per year in n/a. Additionally you can enter the rain intensity 15.1 for a 15-minute storm when n = 1 in l/(s*ha).

Default values are n=0.2 and 100 l/(s*ha).

Computation

In the "Computation" section, a "pre-dimensioning" of the element takes place automatically. In addition to the volume (in m³) actually available shown in the field titled "existing impound volume", the required volume (in m³) is shown in the field labled "required impound volume". If the exisiting volume is not sufficient, the output is shown in red lettering, otherwise in green lettering.

Pre-dimensioning occurs in accordance with the German guidelines from ATV-Arbeitsblatt A138.

Fit Dimensions
In the "Fit Dimensions" section, you can adjust the element's volume to the requried volume. The required volume is determined from pre-dimensioning or from the long-term simulation, in case this has been completed.
Choose whether you want to adjust length, width or depth. In the "existing value" field, the current value is shown. In the "required value" field, the newly calculated value is shown. This is the value required to provide enough storage volume. If the existing value is not enough, the output is shown in red lettering, otherwise in green lettering.
By clicking on the "Fit" button, the adjustment is made; i.e. the current value is saved.

Trenches: Throttle Tab

In the properties dialog for trenches you'll find the "Throttle" tab.

Throttle Performance

In the "Throttle Performance" section you can enter an area-specific throttle intensity. The default value is 10 l/(s*ha). At the sime time, the discharge is automatically calculated as a function of connected runoff-effective surface. If the "autom." checkbox is deactivated, you can manually define an element-specific throttle capacity in the "max. throttle" field. The max. throttle capacity is reached when the trench is full. The programme calculates the throttle characteristic curve from this, in case it is not entered manually.

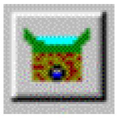
Throttle Characteristics

In the "Throttle Characteristics" section, the trench's throttle characteristic curve is defined. The throttle curve depicts the throttle capacity (in l/s) as a function of water level h (in m).

If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise, the curve can be set manually.

Choose Throttle Destination
In the section titled "Choose Throttle Destination" you can select any element as a destination for the throttled discharge.

1.3.10.1.6 Swale-Trench Elements

 You can add new swale-trench elements with this button, via the context menu (right mouseclick) or via the menu option "Add new..." in the "System Elements" pulldown menu.

A swale-trench element is includes the "swale" and "trench" components. The calculation approaches are essentially equal and deliever - at least with the same input parameters - the same results.

After entering the designation and location of the swale-trench element, its geometry must be entered in the "Swale Dimensions" tab. If the shape of the swale deviates from the standard (obelisk), a volume curve should be entered as with the cisterns.

In the "Infiltration" tab, the data for the infiltration out of the trench is entered. The indicative kf-value for the infiltraion can be directly inputted or determined by selecting a soil type. The specification for an infiltration destination is generally the underlying trench. If necessary, a separate infiltration surface curve can be entered along the lines of the volume characteristic curve. At the same time, the infiltration capacity of the surrounding soil under the trench is specified.

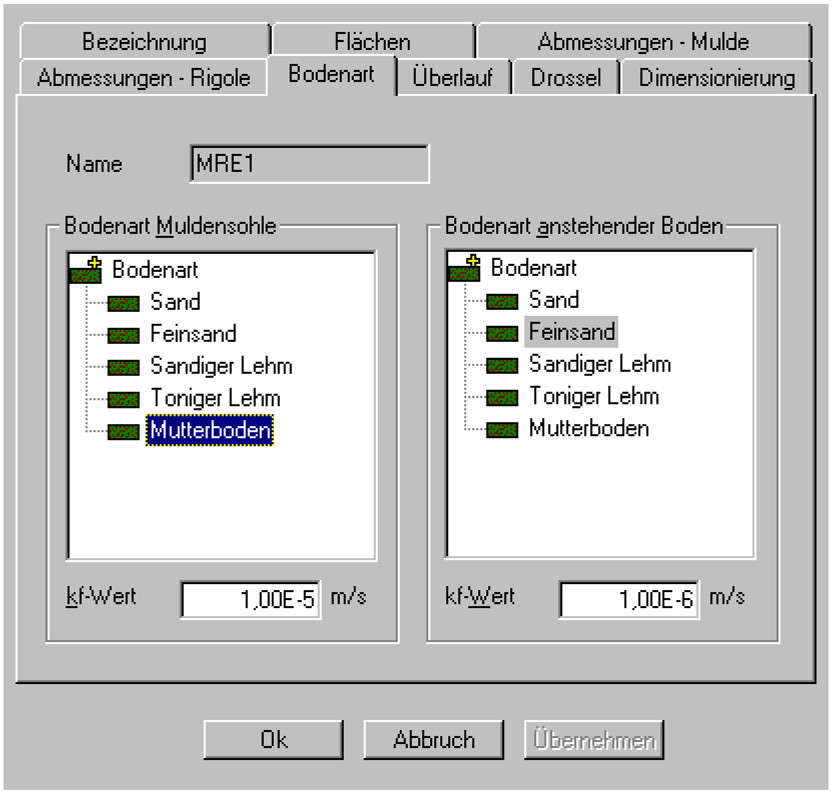


Figure 3-36: Entering the infiltration parameters for a swale-trench element

Specifications as to overflow hight and overflow capacity are given in the "Overflow" tabs. The overflow capacity is normally determined automatically by the programme. If required, a separate overflow curve can be entered along the lines of the volume characteristic curve. Indicating an overflow destination may only be possible later when all drainage elements have been entered.

The inflow to the swale-trench element can be controlled in the "Surfaces" tab.

In the "Dimensioning" tab, you can check whether the geometry of the swale and the trench (dimensions and overflow hight) is enough to provide the required volume, considering the overflow capacity, rain intensity and the assumed proportion of available and discharge-effective area. The geometry of the swale and trench can be fit to the required storage volume by selecting one dimension (length, width or depth) and clicking the "Fit" button (see Figure 3-33).

Mulden-Rigolen-Element: Versickerung

Im Eigenschaftsdialog des “Mulden-Rigolen-Elementes” finden sie das Eigenschaftsdialog "Versickerung". Hier können Sie die Bodenart für die Versickerung aus der Mulde (Muldensohle) und der Rigole (Rigolensohle) angeben.

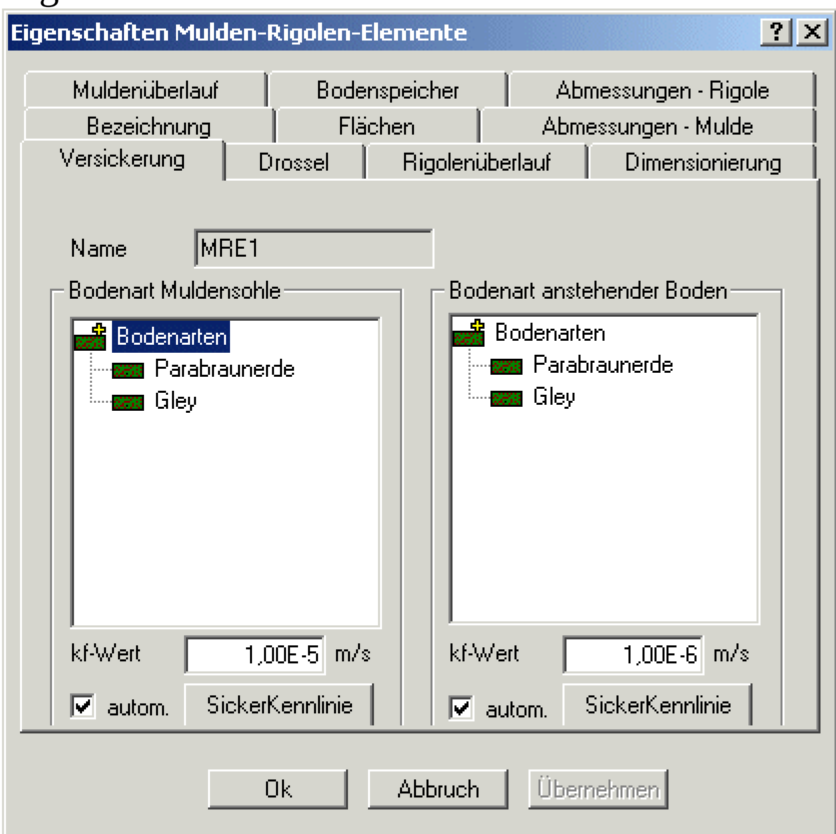


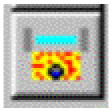
Abbildung 1-113: Erfassung der Versickerungsparameter eines Mulde-Rigolen-Elementes

Bodenart Muldensohle, Bodenart anstehender Boden

In den Bereichen “Bodenart Muldensohle” und “Bodenart anstehender Boden” können Sie Art des durchsickerten Bodens angeben. Für die Mulde wird dies standardmäßig der Mutterboden (Muldenbett unter der Mulde) sein. Für die Rigole ist diese Angabe abhängig von dem unter der Rigole befindlichen Bodens.

Der **Kf-Wert** wird entsprechend der gewählten Bodenart übernommen oder kann manuell (in m/s, exponentielle Schreibweise ist möglich) eingetragen werden.

1.3.10.1.7 InnodrainŠ

 You can add new InnodrainŠ elements by clicking on this button, via the context menu (right mouseclick) or via the menu option "Add new..." in the "System Elements" pulldown menu.

An InnodrainŠ element is an alternate form of a swale-trench element. The above-ground storage space is realised not through a sloped swale, but rather through a special concrete structure. You can receive more information about this from Igenieurgesellschaft Prof. Dr. Sieker.

After entering the designation and location of the InnodrainŠ element, its geometry must be set in the "Deepbed Dimensions" tab. If the shape of the deepbed deviates from the standard (cube), a volume characteristic curve should be entered like with the cisterns in section 3.11.1.

In the "Infiltration" tab, the data for the infiltration out of the deepbed is entered. The indicative kf-value for the infiltration can be directly entered or determined by selecting a soil type. The specification for the infiltration destination is generally the underlying trench. If necessary, a separate infiltration curve can be entered as with the volume curve. At the same time, the infiltration capacity of the surrounding soil underneath the trench is indicated.

Specifications as to the overflow hight and the overflow capacity can be made in the "Overflow" tabs. The overflow capacity is normally determined by the programme automatically. If necessary, a separate overflow curve can be entered as with the volume characteristic curve. Specifying an overflow destination may only be possible later when all drainage elements have been entered.

The inflow to the InnodrainŠ element can be checked in the "Surfaces" tab.

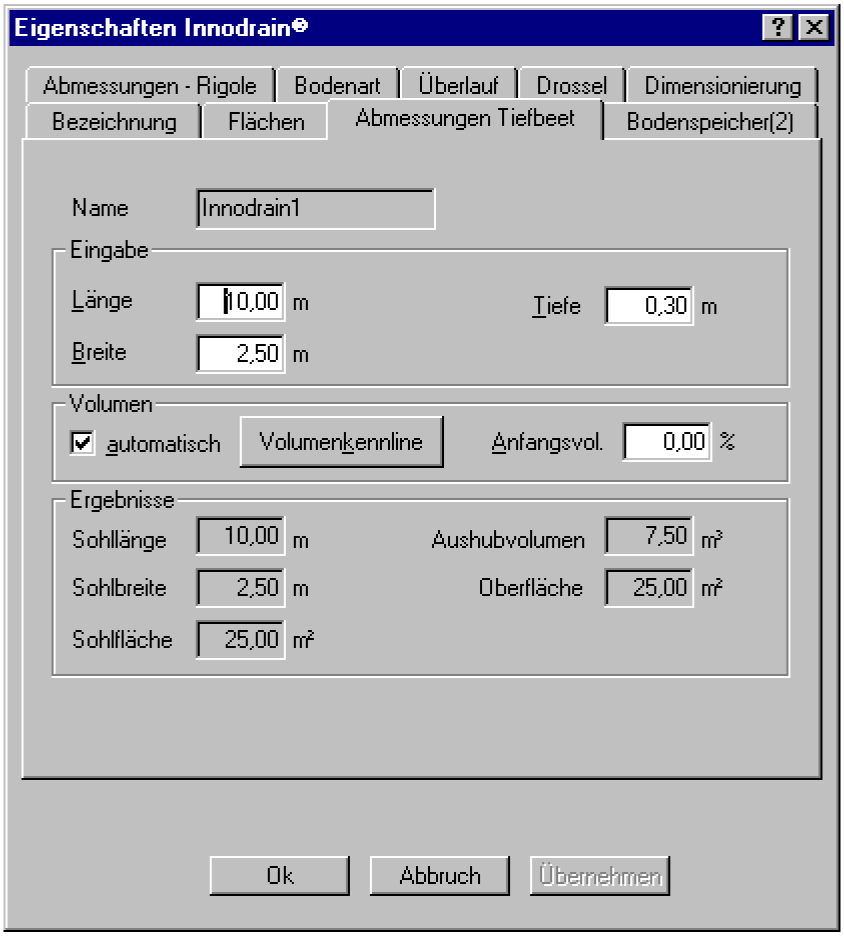
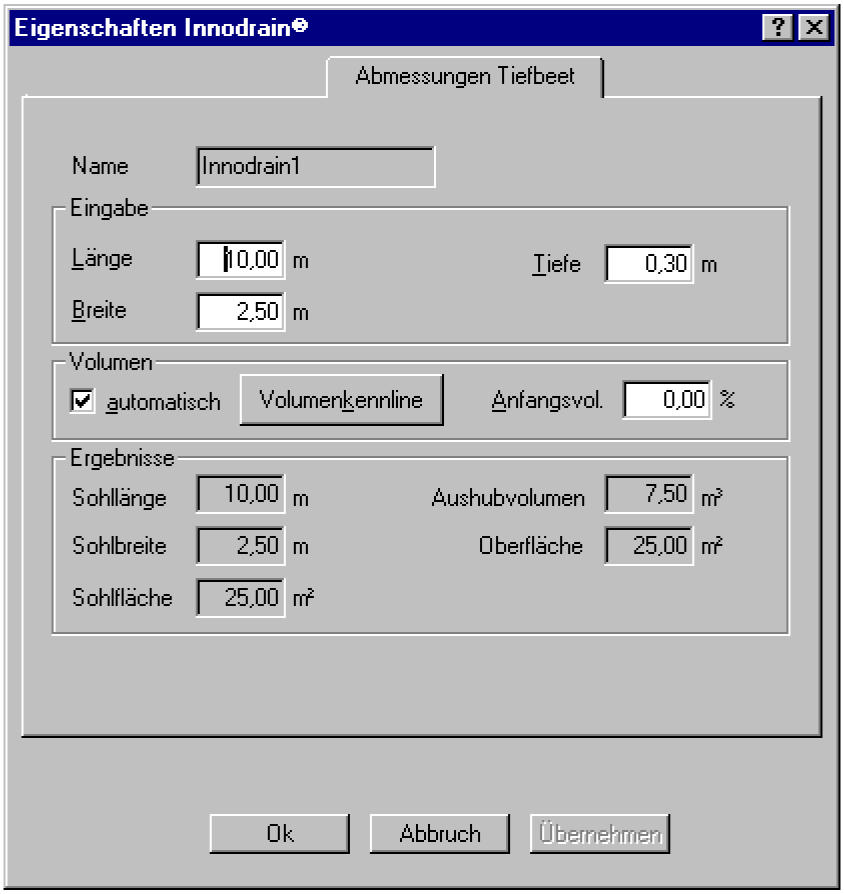


Figure 3-37: Entering the dimensions for a InnodrainŠ element

In the "Dimensioning" tab, you can check whether the geometry of the deepbed and the trench (dimensions and overflow hight) is sufficient to provide enough volume, considering overflow frequency, rain intensity and the assumed proportion of available to discharge-effective surfaces. The geometry of the deepbed and the trench can be fit to the required storage volume by selecting one dimension (length, width, or depth) and clicking the "Fit" button (see Figure 3-37).

Innodrain© Properties: Deepbed Dimensions Tab



In the "Deepbed Dimensions" tab, you define the size and volume of the deepbed.

Input

In the "Input" section you can input the element's *Length Width Depth* All inputs are given in m and are measured based on the upper edge of the element.

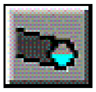
Volume Characteristic Curve

In the "Volume Characteristics" section, the element's volume curve is defined. The volume curve depicts the element's volume (in m^3) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise you can set the curve manually.
You can input an initial volume as a percent of the total storage volume.
Results
In the "Results" section, the the values calculated automatically from the input are given for

- **Bottom length**
- **Bottom width**
- **Bottom surface area**
- **Excavation volume**
- **Upper surface area**

1.3.10.2 Zentrale Regenwasserelemente

1.3.10.2.1 Connecting Pipes



The button shown hier adds a new connecting pipe to drainage elements. The dialog window "Connecting Pipes Properties" is opened to enter data.

First, the designation, any comments and the coordinate values for the connecting pipe are entered in the "Designation" tab. The latter is used to calculate the length of the pipe.

In the "Dimensions" tab, the specifications of the manholes as well as the diameter and the roughness of the pipe are entered (see *Roughness* in Section 6-1 for examples of absolute roughness values based on material type). As a check, the downward gradient of the pipe is determined from the length and the difference in bottom heights. The length of the connecting pipe can be given directly as input or be determined from coordinate entry values with the "Accept" button (see Figure 3-38).

The discharge destination of the connecting pipe can be selected in the "Link" tab. Specifying a discharge destination may only be feasible when all drainage elements have been entered.

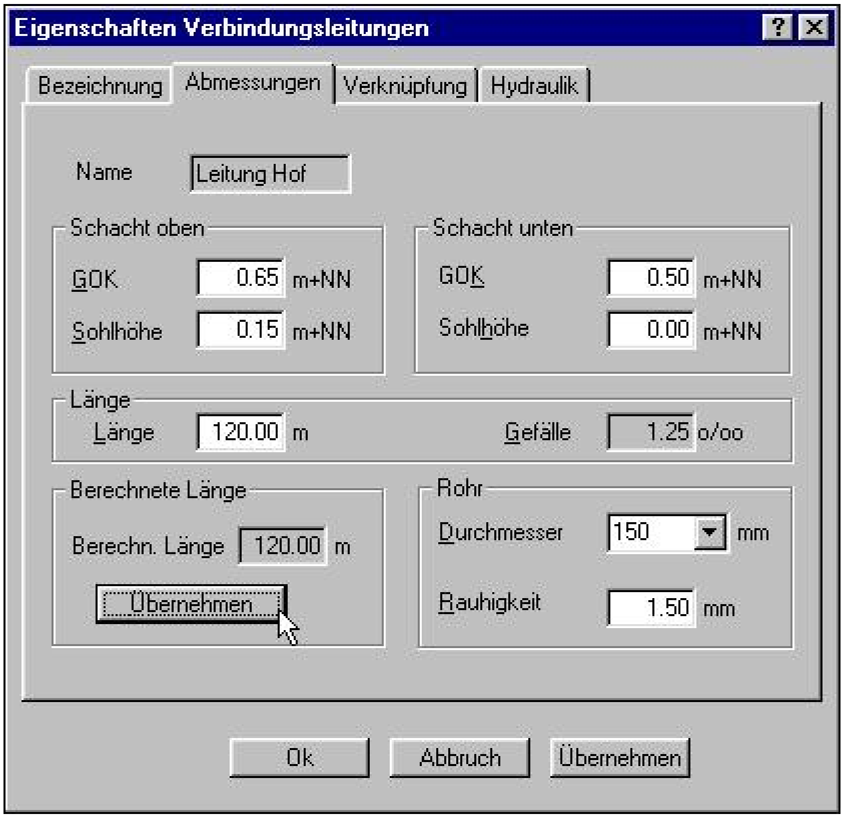
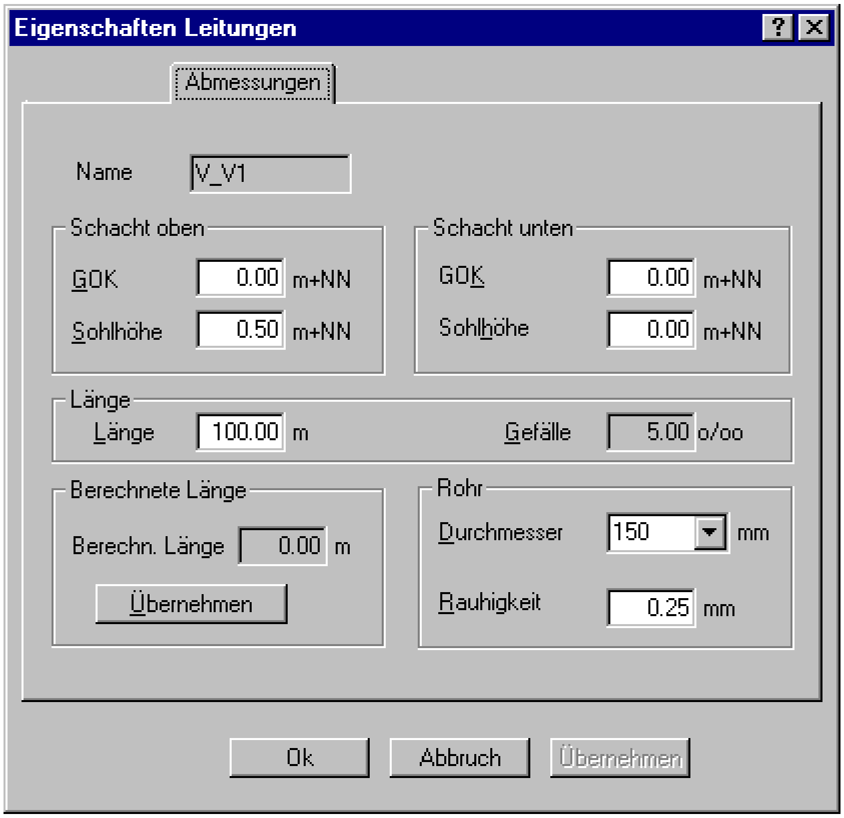


Figure 3-38: Entering properties for connecting pipes

In the "Hydraulics" tab, the available throttle intensity is calculated automatically from the discharges of the elements connected upstream unless manual input is preferred by first deactivating the control box. The flowtime in the pipe is normally calculated from the length and the downward gradient of the pipe.

In the "Retention" section of the "Hydraulics" tab, you can select whether retention should be taken into account for the connecting pipe. If retention is taken into account, the number of storage elements and their corresponding storage constants are automatically calculated from the geometry data.

Sewage Channels: Dimensions Tab



In the properties dialog for sewage channels you'll find the "Dimensions" tab.

Manhole Upstream, Manhole Downstream

In the "Manhole Upstream" and "Manhole Downstream" sections, the elevation of the natural surface and pipe bottom of the relevant channel is entered. All entries should be made in m.

Length
In the "Length" section, the pipe's length (in m) is entered.

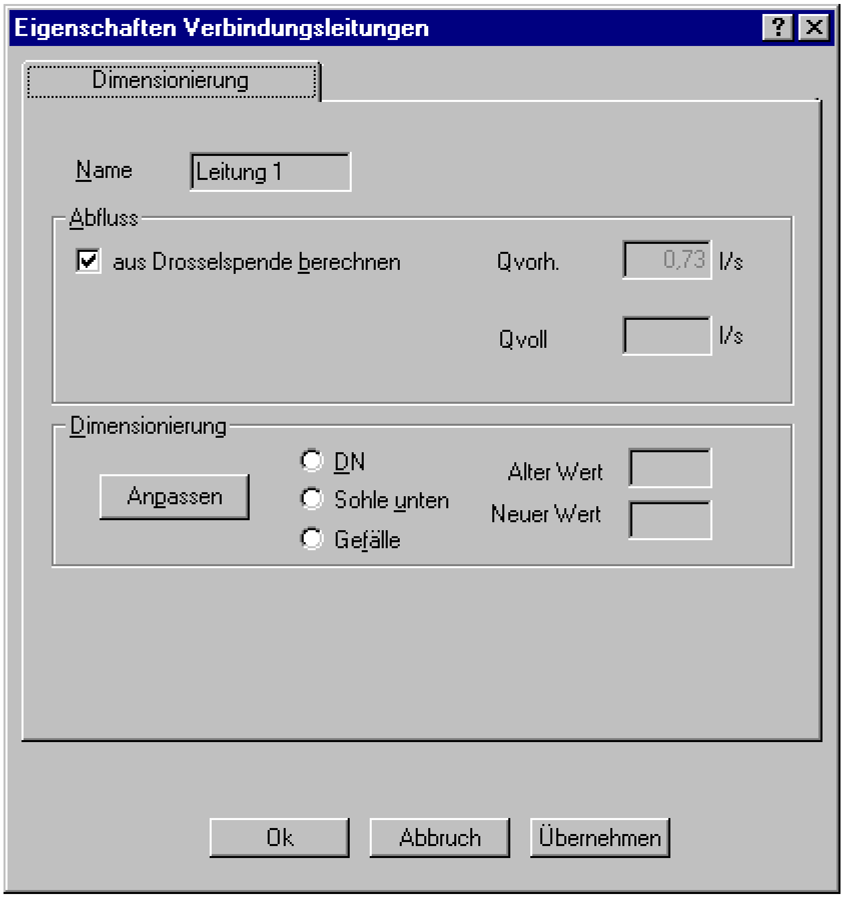
Slope
The slope is calculated automatically from the bottom elevation difference divided by the length.

Calculated Length
In the "Calculated Length" section, the real length of the pipe calculated from the manhole coordinates are shown. With a click on the "Accept" button, you can apply the value for the length.

Canal

In the "Canal" section, the pipe diameter (in mm) and pipe roughness (in mm) are entered in the list field.

Sewage Channels: Dimensioning Tab



In the properties dialog for sewage channels you'll find the "Dimensioning" tab.

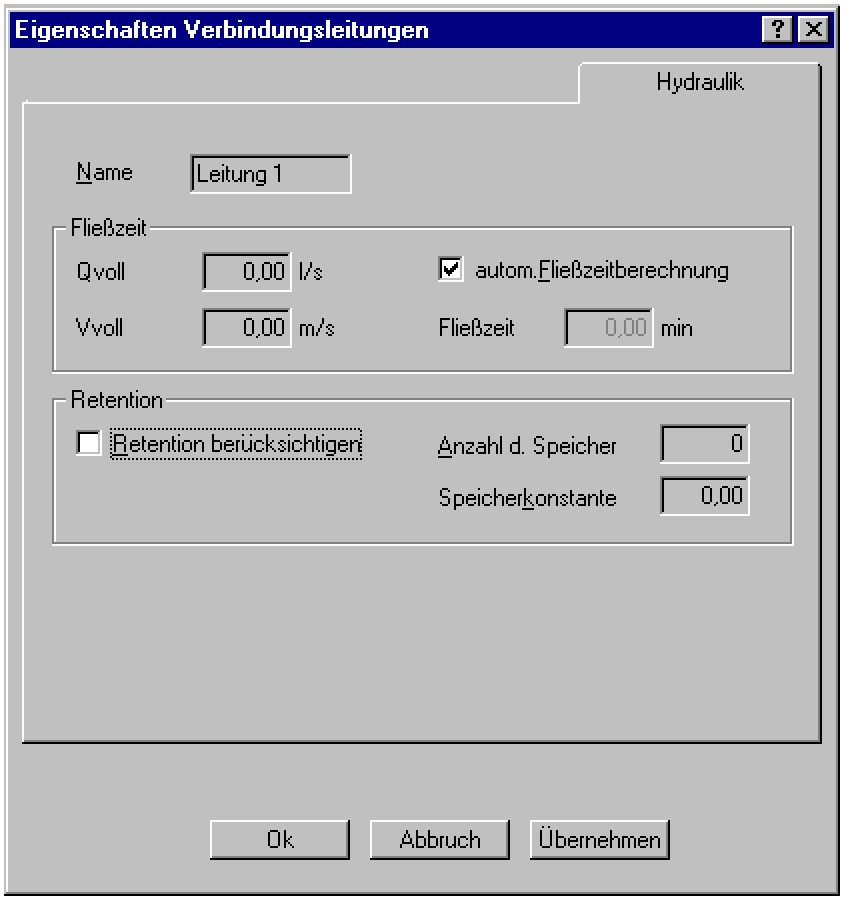
Discharge

In the "Discharge" section, the discharge is calculated as Qfull (in l/s) and Qexist (in l/s) from the (throttled) discharges from elements connected upstream. You can, however, manually enter these by deactivating the checkbox.

Dimensioning

In the "Dimensioning" section, you have the possibility to adjust the element's size to the required value. Choose whether you want to adjust DN, the bottom or slope. In the "Old value" field, the current value is shown. By clicking on the "Fit" button, the adjustment is made. The newly calculated value is indicated in the "New value" field.

Sewage Channels: Hydraulics Tab



In the properties dialog for sewage channels you'll find the "Hydraulics" tab.

Flow Time

In the "Flow time" section, the flow time is calculated from the length and slope of the pipe. You can, however, also enter this manually by deactivating the checkbox. The values for full pipe capacity Qfull and its respective flow velocity Vfull are automatically calculated and shown.

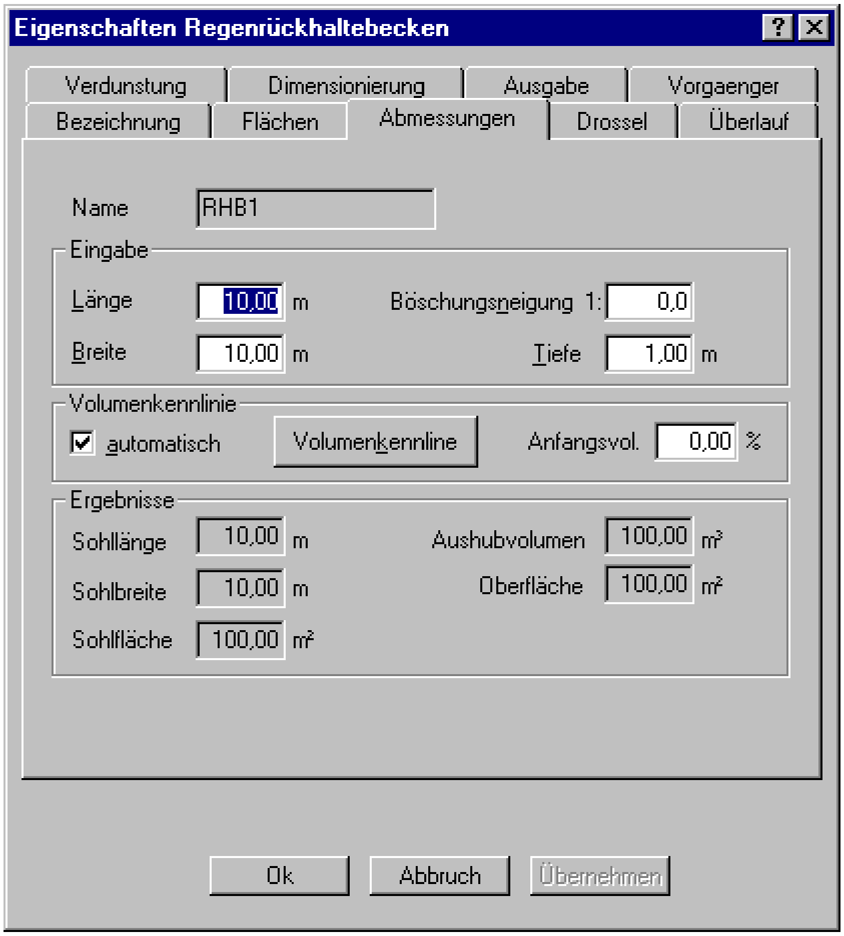
Retention

In the "Retention" section you have the possibility to take a retention in the pipe into account by clicking on the checkbox.

1.3.10.2.2 Stormwater Retention Tanks

You can add new stormwater retention tanks by clicking on this button, via the menu option "Add new" in the "System Elements" pulldown menu, or via the context menu (right mouseclick).
After inputting the designation and location of the stormwater retention tank, its geometry must be entered in the "Dimensions" tab. If the shape of the tank deviates from the standard (obelisk), you should enter a volume characteristic curve.
The throttle discharges from the retention tank are entered by specifying the area-specific throttle intensity in the "Throttle" tab. At this point, there is an automatic calculataion of the discharge capacity against the connected discharge-effective surface. The minimum throttle capacity applies to the empty tank and the maximum throttle capacity is reached when the tank is full. From here, the throttle curve is determined if it is not entered manually.
Specifications as to the overflow hight and overflow capacity can be made in the "Overflow" tab. The overflow capacity is normally calculated by the programme automatically. If required, a separate overflow curve can be entered as with the volume characteristic curve. Specifying an overflow destination may only be possible when all drainage elements have been entered.
The inflow to the rainwater retention tank can be controlled in the "Surfaces" tab.
In the "Dimensioning" tab you can check whether the measurements for the retention tank (dimensions and overflow hight) are sufficient to provide the required volume, considering overflow frequency, rain intensity and flowtime. When using a retention tank in the shape of an obelisk, you can fit the dimensions to the required storage volume by selecting one parameter (length, width or depth) and clicking on the "Fit" button.
In the "Output" tab, you can indicate the number of standard impound events. A check box allows the output of each single event in the result report.

Stormwater Retention Tanks: Dimensions Tab



In the properties dialog for stormwater retention tanks, you'll find the "Dimensions" tab.

Input

In the "Input" section you can enter the element's *length*

width

depth

All entries should be given in metres and relate to the upper edge of the tank. Additionally, the embankment slope should be given (in 1:x).

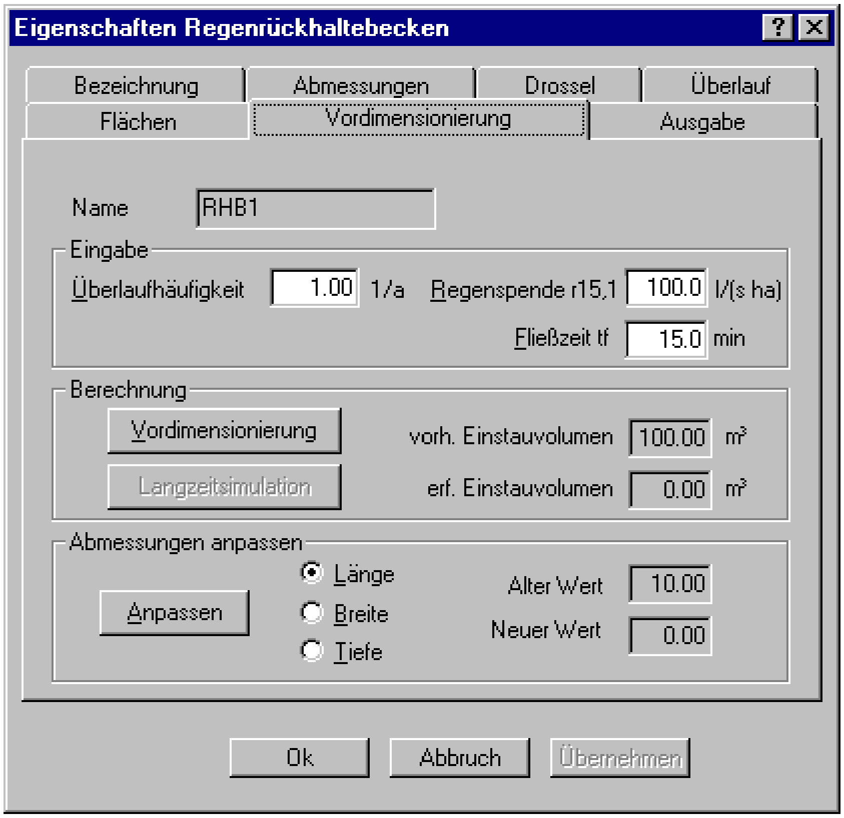
Volume Characteristic Curve

In the "Volume Characteristics" section, the element's volume characteristic curve is defined. The volume curve depicts the element's volume (in m^3) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise, the curve can be set manually.
You can enter an initial volume as a percent of total storage volume.
Results
In the "Results" section, the values calculated automatically from the inputs are shown for *bottom length*
bottom width
bottom surface area

volume and

surface area

Stormwater Retention Tanks: Dimensioning Tab



In the properties dialog for stormwater retention tanks, you'll find the "Dimensioning" tab.

Input
In the "Input" section, you can enter the overflow frequency per year as n/a. Additionally, you can enter the rain intensityr 15,1 for a 15-minute storm when n=1 in l/(s*ha).
Default values are n=0.2 and 100 l/(s*ha).
In the the "Flowtime" input field you enter the flowtime according to the German standards in ATV-Arbeitsblatt A117(1977).

Computation

In the "Computation" section, a pre-dimensioning for the element is undertaken automatically. Additionally to the actually existing volume shown in the "existing impound volume" field (in m^3), the required volume is shown in the "required impound volume" field (in m^3). If the existing volume is not enough, the output is shown in red lettering, otherwise in green lettering.

Pre-dimensioning occurs according to the German standards in ATV-Arbeitsblatt A117 (1977). A consideration of upstream stormwater retention tanks according to A117 does not occur during pre-dimensioning!

Fit Dimensions

In the "Fit Dimensions" section, you have the possiblity to adjust the element's volume to the required volume. The required volume is known from pre-dimensioning, or from long-term simulation, if this has been carried out.

Select whether the length, width, or depth should be adjusted. In the "Existing Value" field, the current value is shown. In the "Required Value" field, the newly calculated value is shown. This is the value that is required in order to provide the required storage volume. If the existing value is not enough, the output is shown in red lettering, otherwise in green lettering. Clicking on the "Fit" button adjusts the dimensions; i.e. the current value is saved.

Stormwater Retention Tanks: Throttle Tab

In the properties dialog for stormwater retention tanks, you'll fine the "Throttle" tab.

Throttle Performance

In the "Throttle Performance" tab, you can preset an area-specific throttle intensity. The default value is 10 l/(s*ha). At the same time, the discharge is automatically calculated as a function of the connected runoff-effective surface.

If the "autom." checkbox is deactivated, you can manually define an element-specific throttled discharge capacity in the "max. throttle" and "min. throttle" fields. The min. throttle capacity applies to the empty tank. The max. throttle capacity is reached when the trench is full. The throttle characteristic curve is calculated automatically by the progamme in case it is not entered manually.

Throttle Characteristic Curve

In the "Throttle Characteristics" section, the tank's throttle curve is defined. The throttle curve depicts the throttle capactiy (in l/s) as a function of water level h (in m).

If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise you can enter the curve manually.

Choose Throttle Destination
In the "Choose Throttle Destination" section, you can choose any element as the destination for throttled discharge.

Eigenschaften Regenrückhaltebecken: Verdunstung

Im Eigenschaftsdialog der Systemelemente “Regenrückhaltebecken” finden sie das Eigenschaftsdialogfeld "Verdunstung".

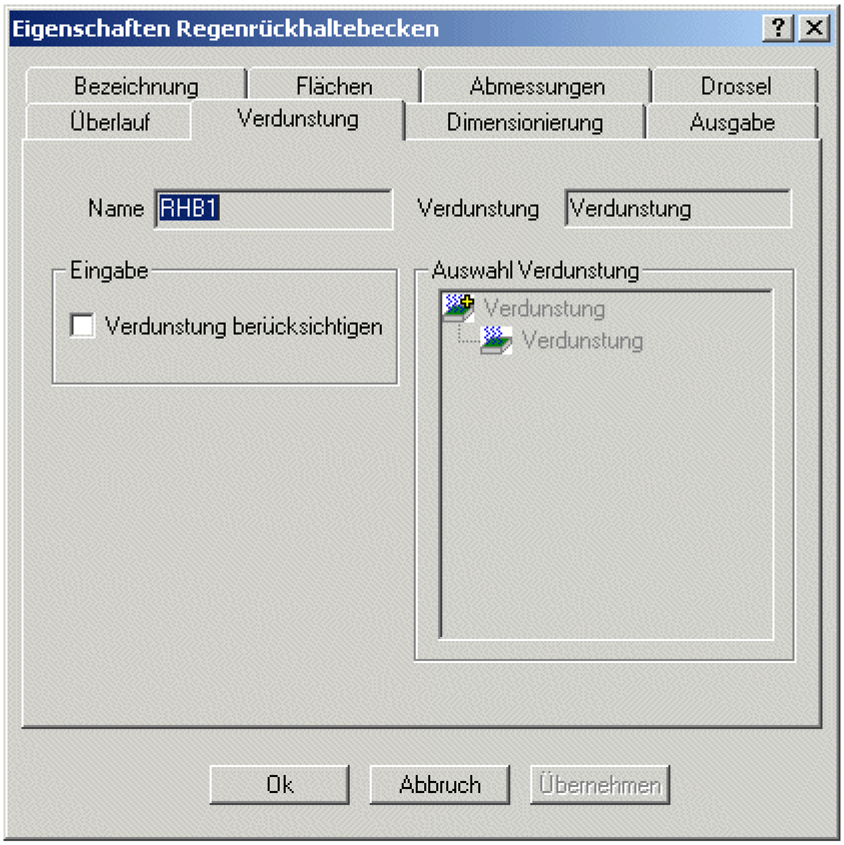


Abbildung 1-122: Verdunstungsparameter eines Regenrückhaltebecken

Geben Sie im linken Bereich *Eingabe* an, ob für das Regenrückhaltebecken eine Verdunstung berücksichtigt werden soll und wählen Sie anschliessend im rechten Bereich den zu verwendenden Verdunstungsparametersatz aus.

1.3.10.2.3 Stormwater Sedimentation Tank

You can add new stormwater sedimentation tanks via the context menu (right mouseclick), via the menu option "Add New" in the "System Elements" pulldown menu, or by clicking on this button.
In the "Designation" tab in the properties dialog, the name and location is entered first. In the "Dimensions" tab, the length, width and depth should be entered in metres.

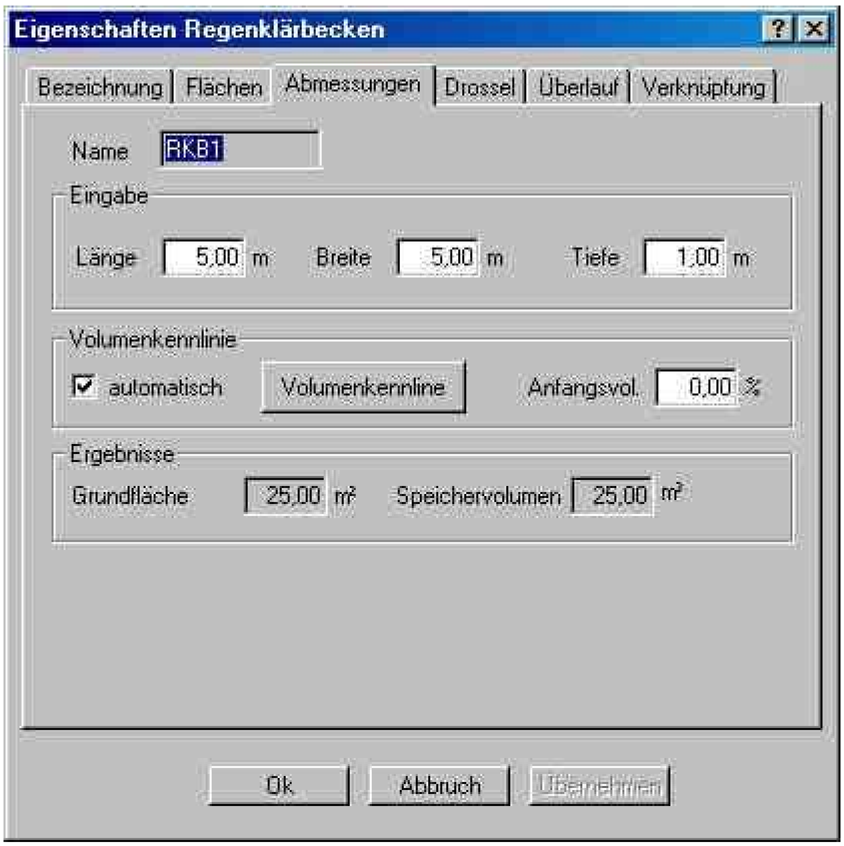


Figure 3-39: Entering the dimensions for a stormwater sedimentation tank

In the "Volume Characteristics" section, the volume curve for the element is defined. The volume curve depicts the element's volume (in m^3) as it relates to the water level (in m). If the "automatic" box is checked, the volume curve is automatically calculated. It is, however, also possible to manually enter a characteristic curve.
In the "Results" section, the automatically calculated values for bottom area and storage volume are indicated.

In the "Throttle Performace" area of the "Throttle" tab, you can preset an area-specific throttle intensity. The default value is 10 l/(s*ha). Here, the discharge capacity is automatically calculated against the connected discharge-effective surface.
If the "automatic" box is deactivated, you can manually define an element-specific throttle discharge capacity in the fields "max. Throttle" and "min. Throttle". The maximum throttle capacity is reached when the trench is full, whereas the minimum throttle capacity applies to the empty tank. From these values, the programme calculates the throttle curve in case it is not entered manually.

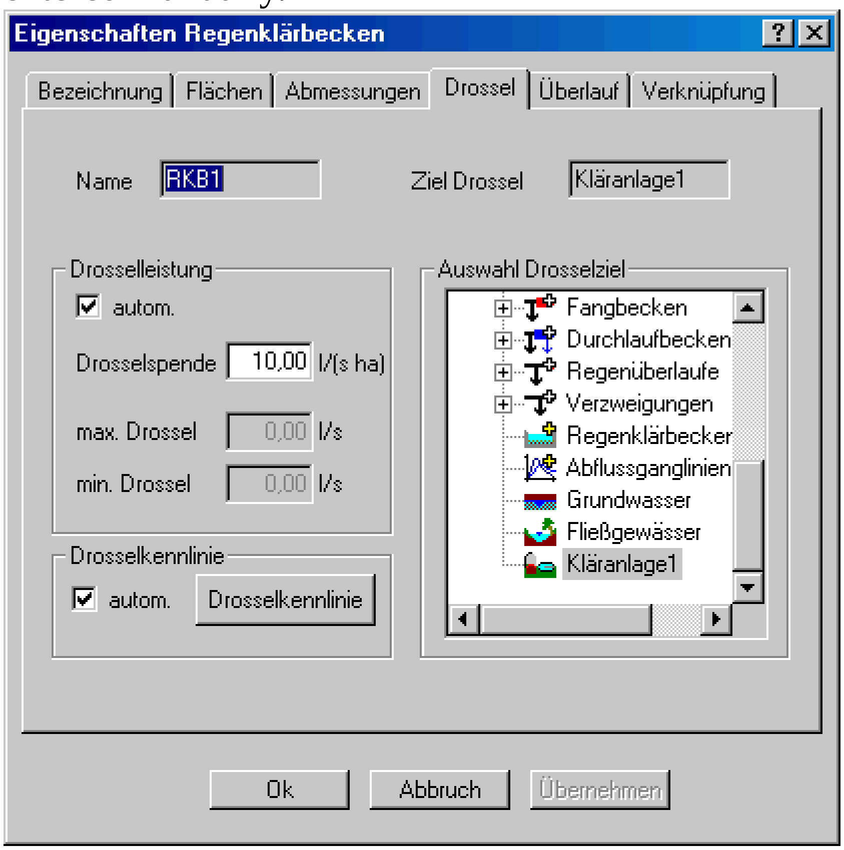
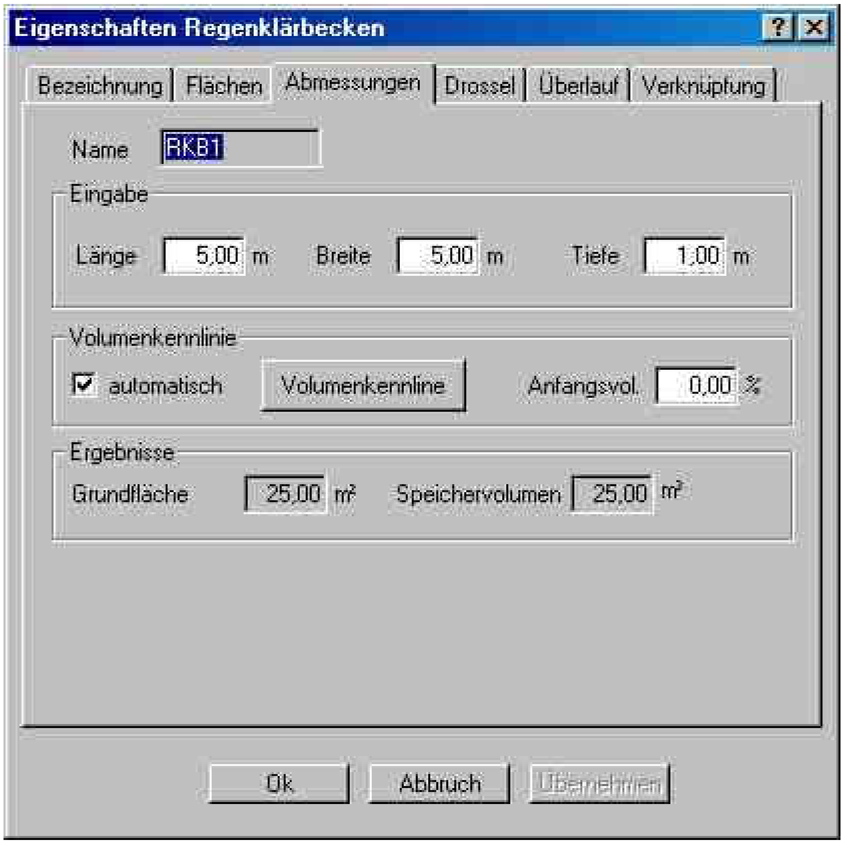


Figure 3-40: Entering the throttle capacity for a stormwater sedimentation tank

In the "Throttle Characteristics" section, the throttle curve for the sedimentation tank is defined. The throttle curve depicts the throttle capacity (in l/s) as it relates to the water level (in m). If the "autom." checkbox is activated, the curve is automatically calculated. Otherwise the curve can be entered manually.
Any element can be selected as the throttle destination.

Stormwater Sedimentation Tanks: Dimensions Tab



In the properties dialog for "stormwater sedimentation tanks" you'll find the "Dimensions" tab.

Input

In the "Input" section you can enter the element's *length*

width

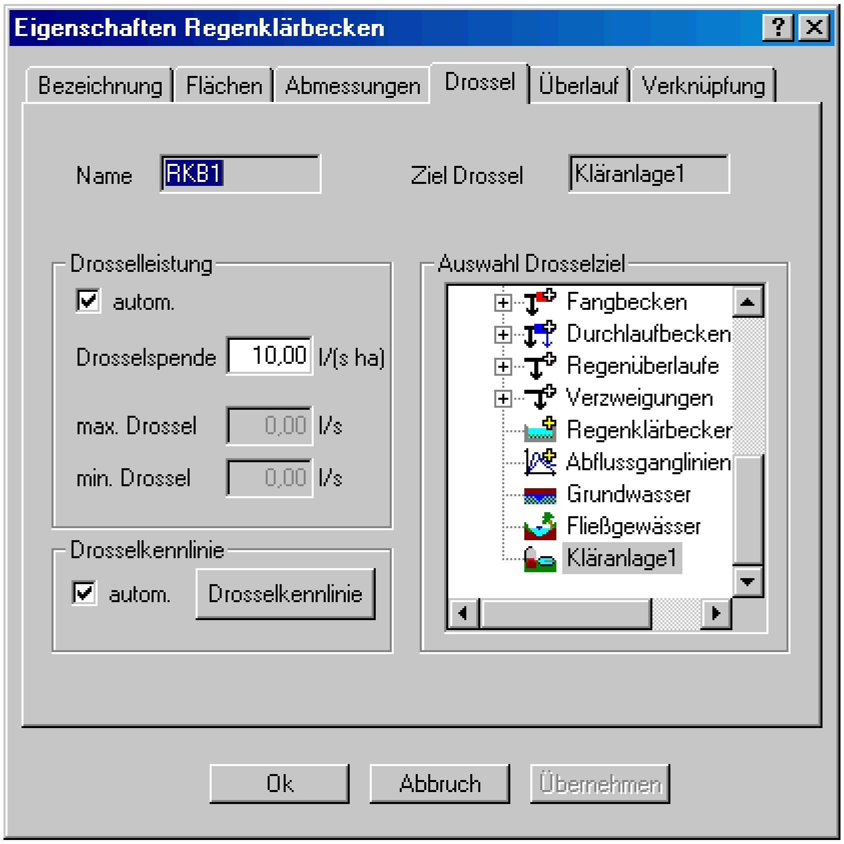
depth

All entries should be made in metres.

Volume Characteristic Curve

In the "Volume Characteristics" section, the element's volume characteristic curve is defined. The volume curve depicts the element's volume (in m^3) as a function of water level h (in m).
If the "autom." control box is activated, the curve is calculated automatically. Otherwise you can set the curve manually.
You can enter an initial volume as a percent of total storage volume.
Results
In the "Results" section, the values calculated automatically based on the inputs are given for storage volume and surface area.

Stormwater Sedimentation Tanks: Throttle Tab



In the properties dialog for stormwater sedimentation tanks, you'll find the "Throttle" tab.

Throttle Performance

In the "Throttle Performance" section you can preset an area-specific throttle intensity. The default value is 10 l/(s*ha). At the same time, the discharge is automatically calculated as a function of the connected runoff-effective surface.

If the "autom." checkbox is deactivated, you can manually define an element-specific throttled discharge capacity in the fields "max. throttle" and "min. throttle". The min. throttle capactiy applies to the empty tank. The max. throttle capacity is reached when the trench is full. The programme automatically calculates the throttle characteristic curve in case it is not manually entered.

Throttle Characteristic Curve

In the "Throttle Characteristics" section, the tank's throttle characteristic curve is defined. The throttle curve depicts the throttle capacity (in l/s) as a function of water level h (in m).

If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise you can set the curve manually.

Choose Throttle Destination
In the "Choose Throttle Destination" section, you can select any element as a destination for the throttled discharge.

1.3.10.2.4 Soil filter

Eigenschaften Bodenfilter: Filtration

Im Eigenschaftsdialog der Systemelemente “Bodenfilter” finden sie das Eigenschaftsdialogfeld “Filtration”.

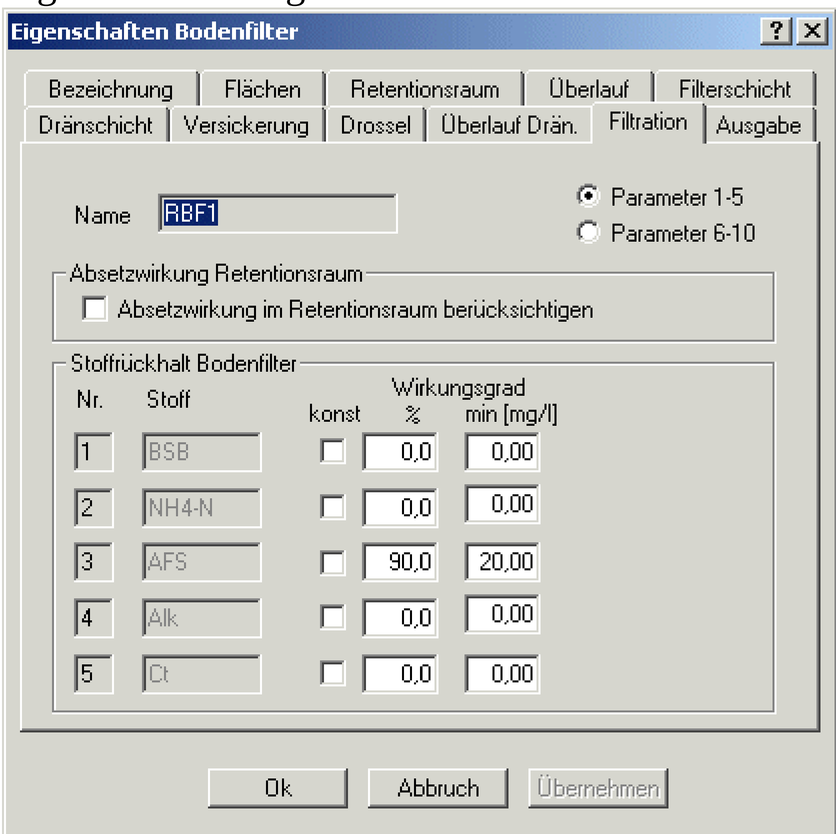


Abbildung 1-125: Erfassung der Filtration eines Bodenfilterbeckens

In diesem Dialogfenster können Sie die Filtrationseigenschaften des Bodenfilterbeckens festlegen. Dabei können Sie für jeden Stoff, den Sie unter "Stoffparameter" festgelegt haben, angeben wie hoch der Wirkungsgrad in % ist, d.h. wieviele Schadstoffe anteilig zu 100 vom Filter zurückgehalten werden.
In der letzten Spalte "min [mg/l]" geben Sie die minimale Stoffbelastung des Wassers in Milligramm pro Lieter an, ab welcher der Filter Schadstoffe zurückhalten kann.
Zusätzlich können Sie festlegen, ob die Absetztwirkung im Retentionsraum mitberücksichtigt werden soll.

Eigenschaften Bodenfilter: Dränschicht

Im Eigenschaftsdialog der Systemelemente “Bodenfilter” finden sie das Eigenschaftsdialogfeld “Dränschicht”.

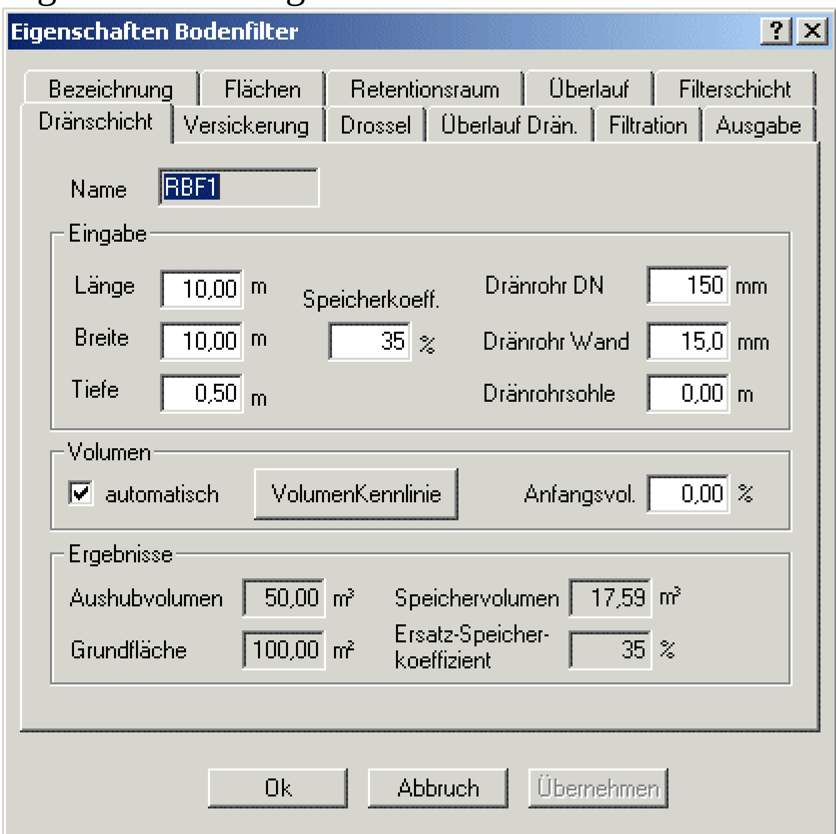


Abbildung 1-126: Erfassung der Dränschichteigenschaften eines Bodenfilterbeckens

Eingabe
Im Bereich "Eingabe" legen Sie die Abmessungen der Dränschicht, sowie die Dimensionierung und Lage des Dränrohres fest.

Volumen

Im Bereich “Volumen” wird die Volumenkennlinie des Elements definiert. Die Volumenkennlinie beschreibt das Volumen des Elements (in m^3) in Abhängigkeit vom Wasserstand h (in m).

Ist das Kontrollkästchen “autom.” aktiviert, wird die Kennlinie automatisch berechnet. Andernfalls kann die Kennlinie manuell angepaßt werden.

Weicht die Form des Beckens von der Standardform (Obelisk) ab, ist eine Volumenkennlinie einzugeben. Des weiteren, kann ein Anfangsvolumen in Prozent vom Gesamtspeichervolumen angegeben werden.

Ergebnisse

Im Bereich “Ergebnisse” werden die aufgrund der Eingabe automatisch berechneten Werte für Grundfläche und Speichervolumen ausgegeben.

Eigenschaften Bodenfilter: Filterschicht

Im Eigenschaftsdialog der Systemelemente “Bodenfilter” finden sie das Eigenschaftsdialogfeld “Filterschicht”.

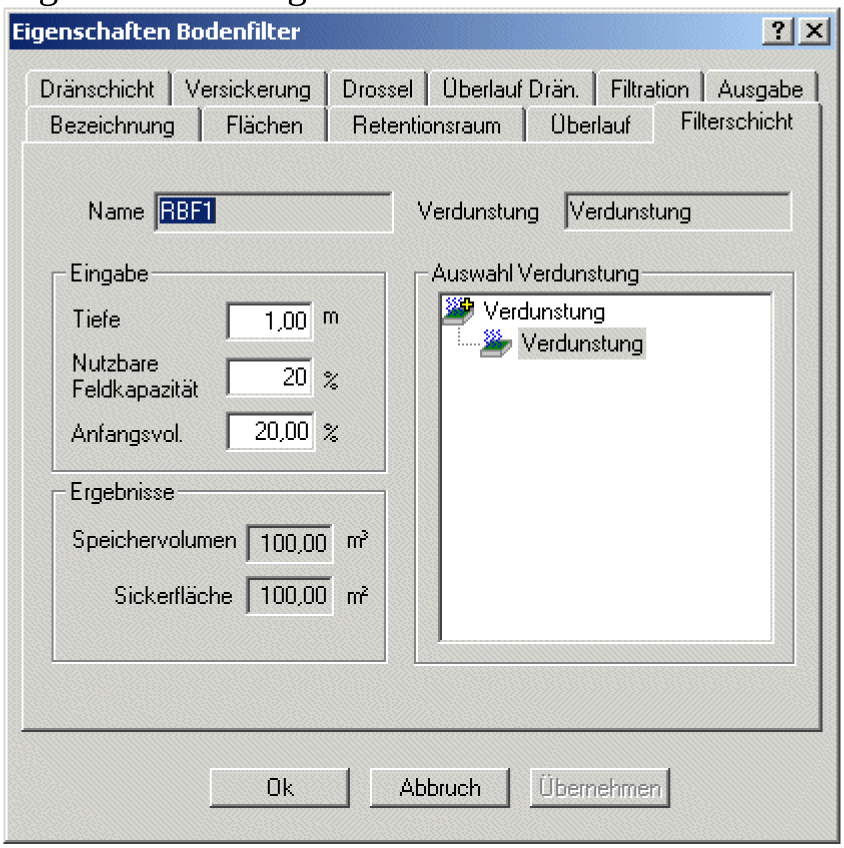


Abbildung 1-127: Erfassung der Filterschichteigenschaften eines Bodenfilterbeckens

In diesem Dialogfeld legen Sie die Eigenschaften der Filterschicht des Bodenfilterbeckens fest.
Im Bereich ***Eingabe*** müssen Sie zunächst die Tiefe der Schicht, die nutzbare Feldkapazität und das Anfangsvolumen angeben, wobei die beiden letzten Werte jeweils prozentual in Bezug auf die gesamte nutzbare Feldkapazität bzw. das Gesamtvolumen genommen werden sollen.
Weiterhin könne Sie der Filterschicht, im Bereich ***Auswahl Verdunstung***, auch einen Verdunstungsparametersatz zuordnen falls dieser bei der Berechnung berücksichtigt werden soll.
In dem unteren Bereich ***Ergebnis*** werden das nach Ihren Angaben automatisch berechnete Speichervolumen sowie die Sickerfläche ausgegeben.

Eigenschaften Bodenfilter: Retentionsraum

Im Eigenschaftsdialog der Systemelemente “Bodenfilter” finden sie das Eigenschaftsdialogfeld “Retentionsraum”.

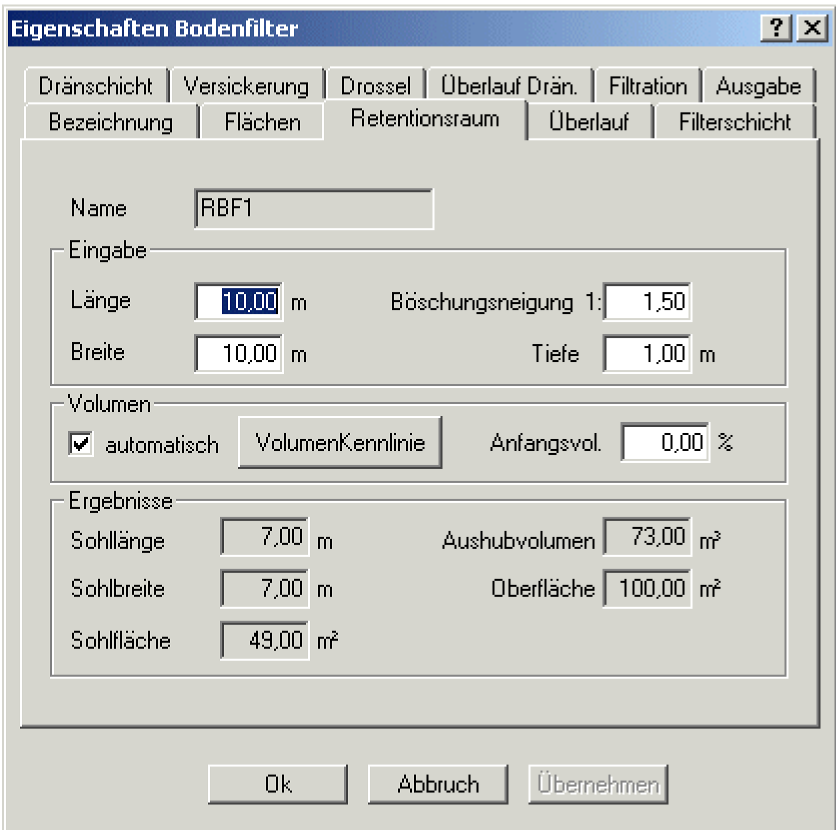


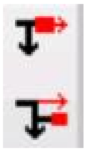
Abbildung 1-128: Erfassung der Abmessungen des Retentionsraumes eines Bodenfilterbeckens

Unter dem Retentionsraum des Filterbeckens verstehen wir den Rückhalteraum oberhalb des Mutterbodenschicht des Bodenfilters.
Für diesen geben Sie zuerst im Bereich ***Eingabe*** die Abmessungen: Länge, Breite, Tiele sowie Böschungsneigung an.
Weicht die Form des Beckens von der Standardform (Obelisk) ab, ist eine ***Volumenkennlinie*** einzugeben.
Ist das Häkchen im Feld „automatisch“ gesetzt, wird die Volumenkennlinie automatisch berechnet. Es ist aber auch möglich eine Kennlinie manuell einzugeben.

Im Bereich der ***Ergebnisse*** werden die automatisch berechneten Werte für Grundfläche und Speichervolumen ausgegeben.

1.3.10.3 Mischwasser-Elemente

1.3.10.3.1 Online or By-pass Retention Tanks

 Via the menu option "Add new" in the "System Elements" pulldown menu, via the context menu (right mouseclick) or by clicking on the upper or lower button, you can add a new online or by-pass retention tank, respectively.
With online retention tanks, the discharge led further to the treatment plant is led directly through the tank.
In contrast, by-pass retention tanks are loaded via a flow-dividing structure. The treatment plant inflow is led past the tank and only after being filled is the tank activated.
In the "Dimensions" tab, the geometry and position of the tank must be entered. After inputting the length, width and hight (in metres), the volume characteristic curve is defined. The volume curve shows the element's volume (in m³) as a function of water level (in m). If the "autom." checkbox is activated, the curve is automatically calculated. Otherwise, the curve can be set manually.
In the "Results" section, the automatically calculated values for the storage volume and the surface area are shown.
In the "Throttle" field, the throttle capacity, characteristic curve, and destination are entered.
In the "Throttle Performance" section, you can preset an area-specific throttle intensity. The default value is 10 l/(s*ha). Here, an automatic calculation of the discharge as a function of the connected discharge-effective surface.
In the "Throttle Characteristics" section, the element's throttle curve is shown. The throttle curve indicates the throttle capacity (in l/s) as a function of the water level (in m). If the checkbox is activated, the curve is automatically calculated. It can, however, be entered manually.
Any element can be selected for a throttle destination.

In the "Overflow" tab, the overflow hight based on the element's impound bottom can be entered in the "Input" section in the "Overflow" input field. The hight generally corresponds to the element's depth.

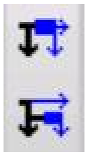
Figure 3-41: Overflow properties dialog for retention tanks

In the "Overflow Performance" section, the threshold length and the overflow coefficient are indicated. If the "autom." checkbox is activated, the overflow capacity is automatically calculated.
The element's overflow curve can be set manually. The overflow curve shows the element's overflow capacity (in l/s) as a function of the water level (in m). By activating the "autom." box, the curve is automatically calculated.
Connected surface can be added and deleted in the "Surfaces" tab.

In the "Output" tab, the type and range of the report can be set.
In the "Output Parameters" section, the number of standard impound events is set. That value determines the extent of the report output as well as the basis for the statistical analysis.
Depending on frequency, it is sensible to give an input of 20-40 impound events.
By clicking on the checkbox "Output of single events", you can set whether the impound events should be outputted in the report or not.

You can sort the events by the following four criteria: Impound- + overflow volume, water level, Qov [l/s] , Qoff [l/s].
In the "Water level hydrograph" tab, you can activate the output of a water level hydrograph for the elemtn by clicking on the checkbox.
When inputting the threshold value, you can suppress the output of zero-values, i.e. periods without a water level, by inputting the lowest value to be reported.
By clicking on the checkbox labeled "calculate over __ intervals", you can set whether the values should be calculated over an indicated interval.
Enter a filename for outputting the .csv-file (values with commas as separators) or set the location and name of the output with the "Browse" button.
The timestep for the file output can be set in the last row with Start and End.

1.3.10.3.2 Online or By-pass Throughflow Tanks

 You can add new online or by-pass throughflow tanks by clicking on the upper or lower button respectively, via the menu option "Add new..." in the "System Elements" pulldown menu, and via the context menu with the right mouse button.
Throughflow tanks feature an overflow for treated water that is activated when the tank is full before it overflows directs the mechanically treated mixed sewage to the receiving waters.
After inputting the designation and location of the throughflow tank, its measurements must be entered in the "Dimensions" tab. In the "Volume characteristics" section, the element's characteristic curve is defined. This indicates the element's volume (in m^3) as a function of water level (in m). By activating the "automatic" checkbox, the volume curve is automatically calculated. Furthermore, it is possible to indicate a starting volume as a percentage of the total storage volume.
The "Throttle" and "Overflow" tabs are filled out just like with retention tanks. (see section 3.13.1)

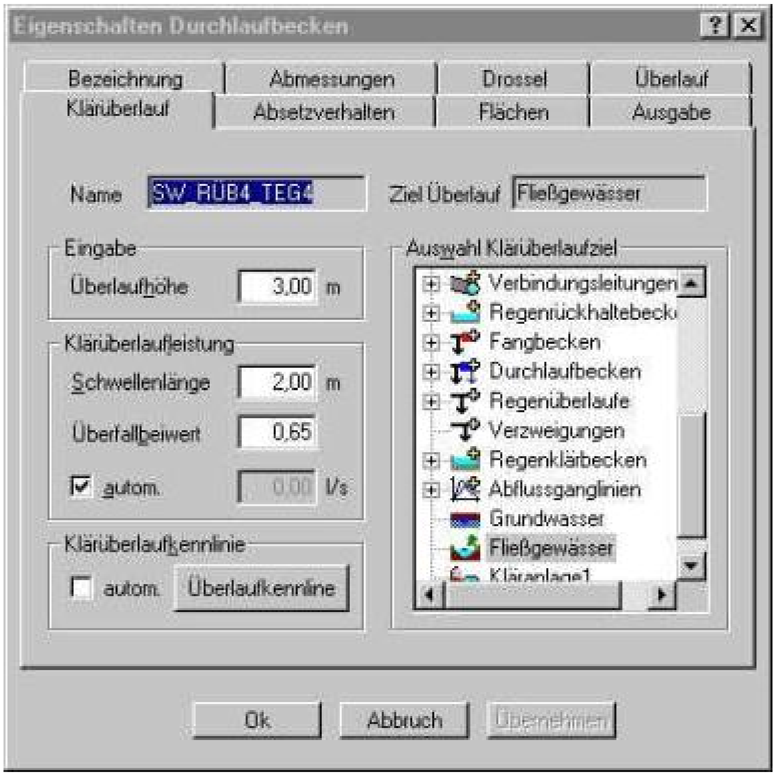


Figure 3-42: "Treated overflow" properties dialog for throughflow tanks

In the "Input" section, you can enter the hight of the treated overflow based on the element's impound bottom in the "Overflow hight" input field. The hight generally corresponds to the element's depth.

The threshold length and the overflow coefficient are indicated in the section titled "Capacity of treated overflow". If the "autom." checkbox is activated, the treated overflow capacity is automatically calculated.

In the "Treated overflow characteristic" section, the element's treated overflow curve is calculated. This shows the element's treated overflow capacity (in l/s) as a function of the water level (in m). If the "autom." checkbox is activated, the curve is automatically calculated. Otherwise, the curve can be set manually.

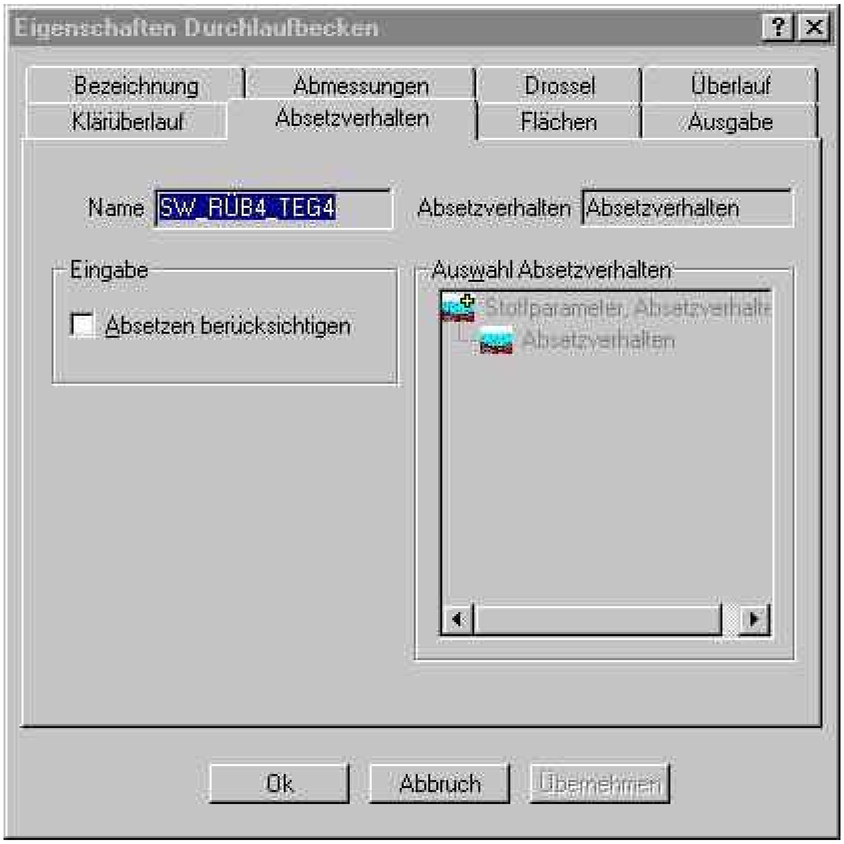


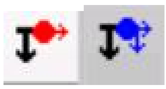
Figure 3-43: Inputting the Sedimentation Behaviour in the "Throughflow tanks" dialog

In the "Sediment Behaviour" tab, you can indicate whether the sediment behaviour should be taken into account. If the "Consider sedimentation" checkbox is activated, you can choose a selection of sedimentation behaviour of substance parameters.

In the section labeled "Choose Sedimentation Behaviour", you can select the sedimentation behaviour of substance parameters that you've defined in the dialog "Substance Parameters, Sedimentation Behaviour".

The "Output" tab is filled out similar to the "Output" tab for retention tanks (see section 3–1).

1.3.10.3.3 Sewers with Storage Capacity, Overlying or Underlying Drain

 You can add new sewers with storage capacity by clicking on one of these buttons, via the menu option "Add new..." in the "System Elements" pulldown menu, and via the context menu by clicking the right mouse button.
As with all combined sewage elements, the name and location are entered in the "Designation" tab first. Then, the dimensions are entered in the "Dimensions" tab. In the "Input" section, you can enter the length in m, the diameter in mm and the slope in %. The volume characteristic curve is defined in the "Volume curve" section. If the "autom." checkbox is activated, the curve is automatically calculated. Otherwise, the curve can be set manually. In the "Results" section, the automatically calculated values for the storage volume are given on the basis of the input.
In the "Throttle" tab, an area-specific throttle intensity can be preset in the "Throttle Performance" section. The default value is 10 l/(s*ha). At this time there is an automatic calculation of the drain pipe as a function of the connected runoff-effective surface.
In the "Throttle Characteristics" section, the element's throttle curve is defined. The throttle curve shows the throttle capacity (in l/s) as a function of th water level (in m). The curve is automatically calculated as soon as the checkbox is activated. Otherwise, the curve can be set manually.
In the section titled "Choose throttle dest." you can select any element as the destination for the throttle discharge.
In the "Overflow" tab, the overflow hight, capacity, curve, and destination can be defined.
In the "Input" section, you can enter the overflow hight, the level of overflow based on the element's impound bottom. The hight generally corresponds to the depth of the tank.
The threshold length and the overflow coeffecient are determined in the "Overflow Performance" section. If you activate the "autom." checkbox, the overflow capacity is calculated automatically.
The overflow curve indicates the element's overflow capacity (in l/s) as a function of the water level (in m). The curve is either automatically

calculated by activating the "autom." checkbox or entered manually.
In the properties dialog for sewers with underlying drains, there is an additional tab labeled "Treated overflow".

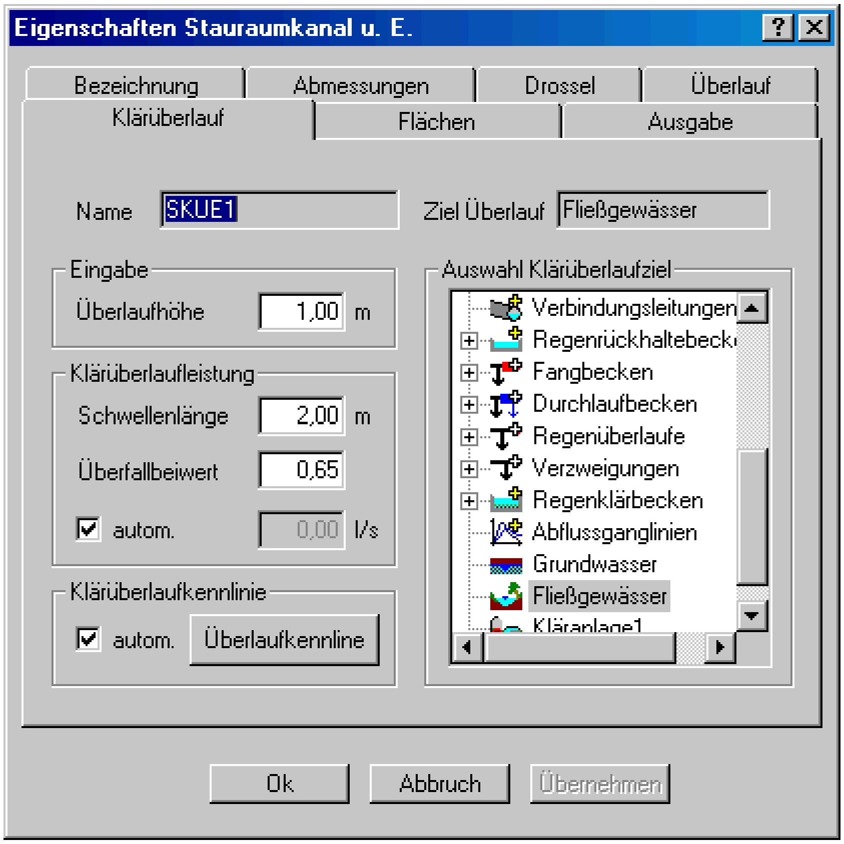
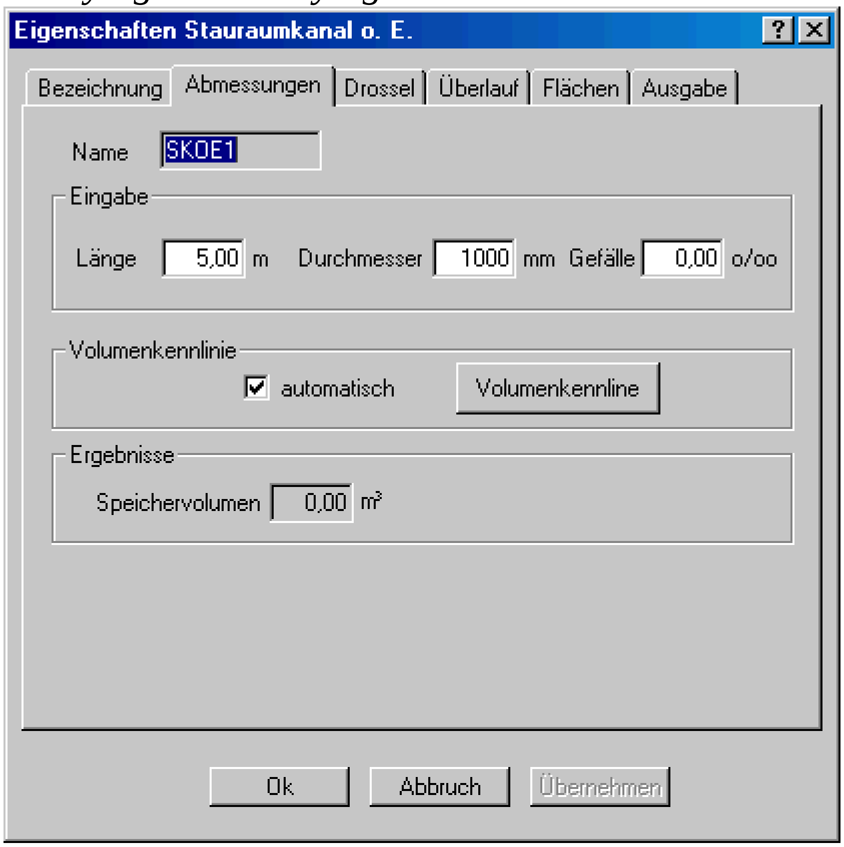


Figure 3-44: "Treated overflow" tab for sewers with storage capacity with underlying drain

The overflow hight indicates the level of the overflow based on the element's impound bottom and is entered in the field "Overflow hight". The overflow hight generally corresponds to the element's depth.
In the "Capacity of treated overflow" section, the threshold length and overflow coefficient are indicated. The treated overflow capacity is automatically calculated whenever the "autom." checkbox is activated.
The element's treated overflow curve is defined in the "Characteristic treated overflow" section. The treated overflow curve shows the element's treated overflow capacity (in l/s) as a function of the water level (in m). If the "autom." checkbox is activated, the curve is automatically calculated. Otherwise, the curve can be set manually.
The "Output" tab is filled out similarly to the "Output" tab for retention tanks (see section 3–1).

Sewer with Storage Capacity: Dimensions

overlying or underlying drain



In the properties dialog for sewers with storage capactiy (regardless of overlying or underlying release) you'll find the "Dimensions" tab.

Input

In the "Input" section you can enter the element's *Length*

Diameter

Slope

The inputs must be made in m, mm and o/oo respectively.

Volume Characteristic Curve

In the "Volume Curve" section, the element's volume curve is defined. The volume curve depicts the element's volume (in m^3) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise, you can set the curve manually.
Results
In the "Results" section, the values for storage volume calculated automatically from the inputs are shown.

Sewer with Storage Capacity, Underlying Release: Treated Overflow Tab

In the properties dialog for sewers with storage capacity with an underlying release, you'll find the "Treated Overflow" tab.

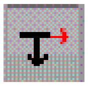
Input

Overflow Hight
In the "Input" section you can enter the hight of the treated overflow based on the element's impound bottom in the "overflow hight" input field. The hight generally corresponds to the element's depth.

Treated Overflow Capacity
In the "Capacity of Treated Overflow" section, the threshold length and the overflow coefficient are entered. If the "autom." checkbox is activated, the treated overflow capacity is calculated automatically.

Treated Overflow Characteristic
In the "Treated Overflow Characteristic" section, the element's treated overflow characteristic is defined. The treated overflow curve depicts the element's treated overflow capacity (in l/s) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise, the curve can be set manually.

1.3.10.3.4 Stormwater Overflow

 You can add new stormwater overflows by clicking on this button, via the menu option "Add new..." in the "System Elements" pulldown menu, and via the context menu by clicking with the right mouse button.
After inputting the name and coordinate values for the stormwater overflow, additional comments can be written as well. This is all completed in the "Designation" tab.
In the "Surfaces" tab, connected surfaces can be added or, if necessary, deleted.
The discharge destination for the overflow can be selected in the "Link" tab.
In the "Throttle" tab in the "Throttle performance" section, you can enter the throttle intensity. When the "autom." checkbox is activated, only the values for the throttle intensity and separation effect. When the checkbox is deactivated, you can indicate the separation effect as well as how many liters per second are discharged when the overflow becomes activated. The separation effect defines the maximum throttle discharge at Qmax.

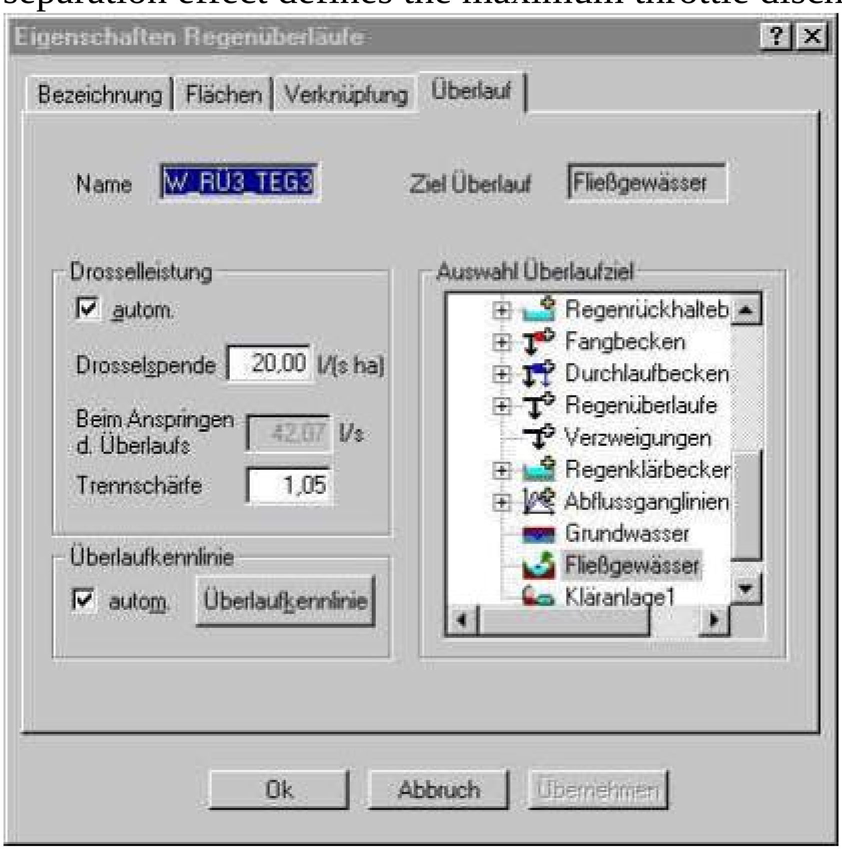
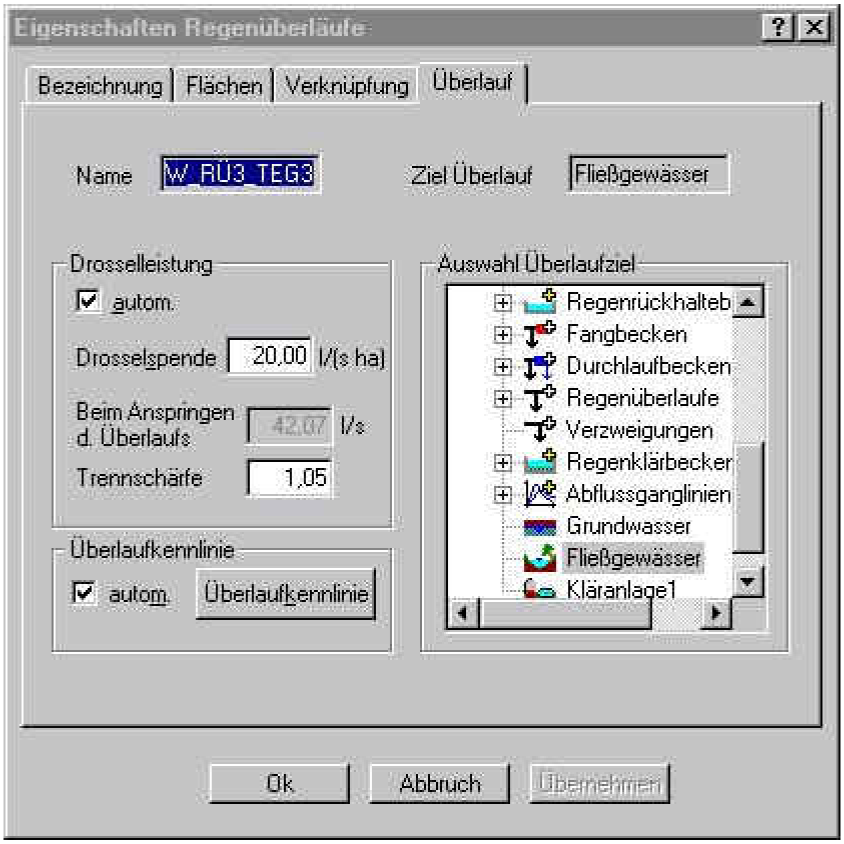


Figure 3-45: "Overflow" tab for stormwater overflows

Defining the overflow curve occurs in the "Throttle Characteristics" section of the "Throttle" tab. The overflow curve shows the element's overflow capacity (in l/s) as a function of the water level (in m). If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise, it can also be set manually.

Stormwater Overflows: Overflow Tab



In the properties dialog for stormwater overflows, you'll find the "Overflow" tab.

Throttle Performance

Überlaufkennlinie
In the "Overflow Characteristics" section, the element's overflow characteristic curve is defined. The overflow curve depits the element's overflow capacity (in l/s) as a function of water level h (in m).
If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise, the curve can be set manually.

Eigenschaften Regenüberlauf: Ausgabe

Im Eigenschaftsdialog des Systemelements "Regenüberläufe" finden sie das Eigenschaftsdialogfeld “Ausgabe”. In dieser Karteikarte können Art und Umfang der Ausgabe festgelegt werden

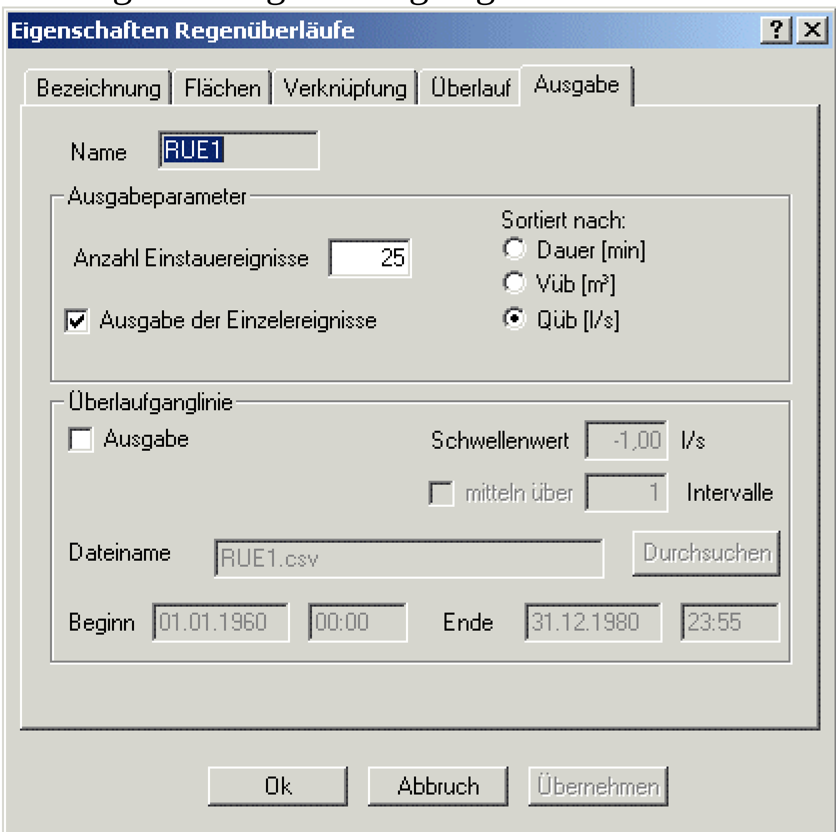


Abbildung 1-135: Eigenschaftsdialogfeld „Ausgabe“ bei Regenüberläufen Im Bereich “***Ausgabeparameter***” wird die Anzahl der maßgebenden Einstauereignisse festgelegt. Der Wert bestimmt sowohl den Umfang der Berichtsausgabe als auch die Grundlage für die statistische Auswertung.

Sinnvoll ist je nach Häufigkeit eine Eingabe von 20 bis 40 Einstauereignissen.

Durch Anklicken des Kontrollkästchens *“Ausgabe der Einzelereignisse”* kann festgelegt werden, ob die Einstauereignisse im Bericht ausgegeben werden sollen oder nicht.

Die Sortierreihenfolge kann nach den folgenden vier Kriterien festgelegt werden: Einstau- + Überstauvolumen, Wasserstand, Qüb [l/s] , Qab [l/s].

Im Bereich “***Überlaufganglinie***” kann die Ausgabe einer Überlaufganglinie für das Element durch des Häkchens im Kontrollkästchen aktiviert werden.

Mit der Eingabe des *Schwellenwertes* können Sie die Ausgabe von Null-Werten, d.h. Zeiten ohne Wasserstand, unterdrücken, indem Sie dort den niedrigsten zu registrierenden Wert eingeben.
Durch Anklicken des Kontrollkästchens *“mitteln über Intervalle”* kann festgelegt werden, ob die Werte über ein angegebenes Intervall gemittelt werden sollen.
Geben Sie einen *Dateinamen* für die Ausgabe der CSV-Datei (Werte mit Komma als Trennzeichen) an oder legen Sie Ort und Name der Ausgabe mit dem Schaltfeld *“Durchsuchen”* fest.
Der *Zeitschritt* für die Ausgabe der Datei kann in der letzten Zeile mit Beginn und Ende festgelegt werden.

1.3.10.3.5 Branchings

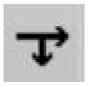
 You can create new branchings by clicking on this button, via the menu option "Add new..." in the "System Elements" pulldown menu, and via the context menu by clicking with the right mouse button.
First the name, location, and comments (if any) are entered in the "Designation" tabZunächst werden die Bezeichnung, der Standort und eventuelle Kommentare im Dialogfenster „Bezeichnung“ eingetragen.
The connected surfaces are entered in the "Surfaces" tab. These can be added and deleted again as necessary.
The branching's destination is entered in the "Link" tab. In the "Choose Destination" tab it is possible to select one of the existing drainage elements.

Figure 3-46: "Branching" tab

In the "Distribution" section of the "Branching" tab, a definite set portion of the inflow can be assigned to the branch. The rest is discharged further to the actual destination.
The branching characteristic curve is defined in the "Branch characteristic" section. If the "autom." checkbox is activated, the curve is calculated automatically. Otherwise, the curve can be set manually.
The branching's destination can be set in the "Branch Destination" section.

1.3.11 Wasserbilanzobjekte

1.3.11.1 Groundwater

1.3.11.2 River/Stream

1.3.11.2.1 Fließgewässer: Gewässergüte

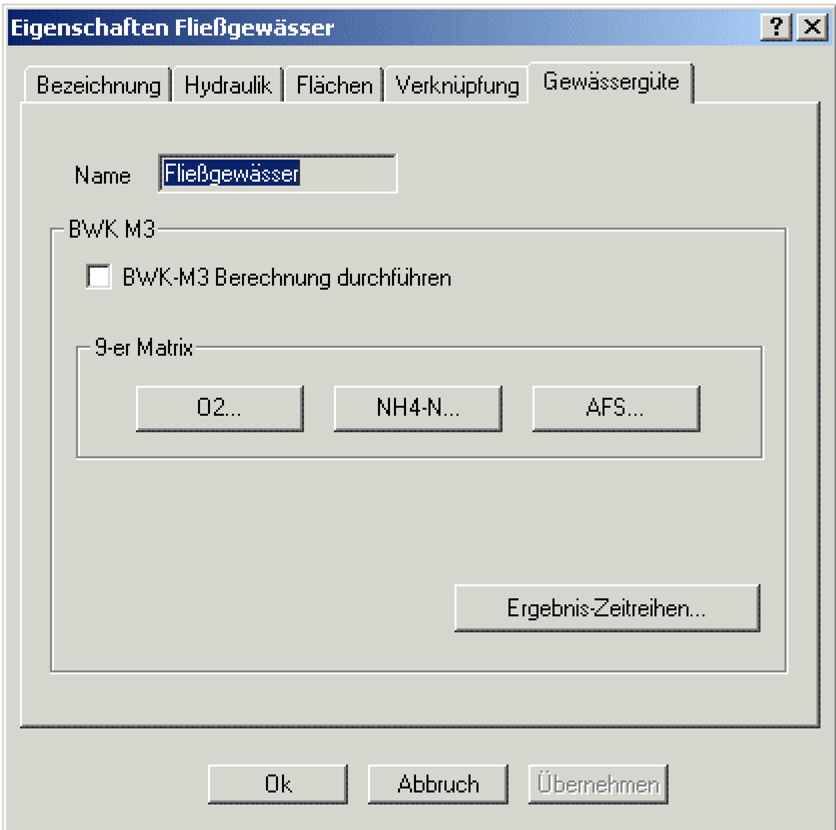


Abbildung 1-138:

Gewässergüte: 9er Matrix

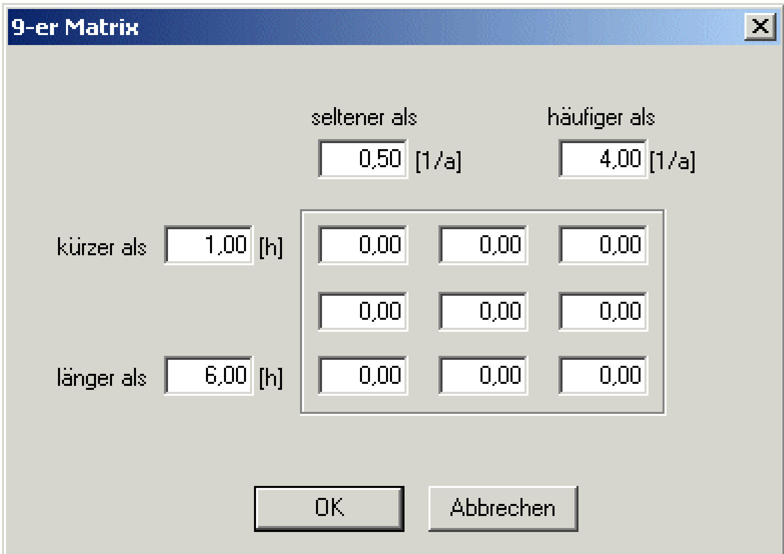


Abbildung 1-139:

Gewässergüte: Ergebniszeitreihe

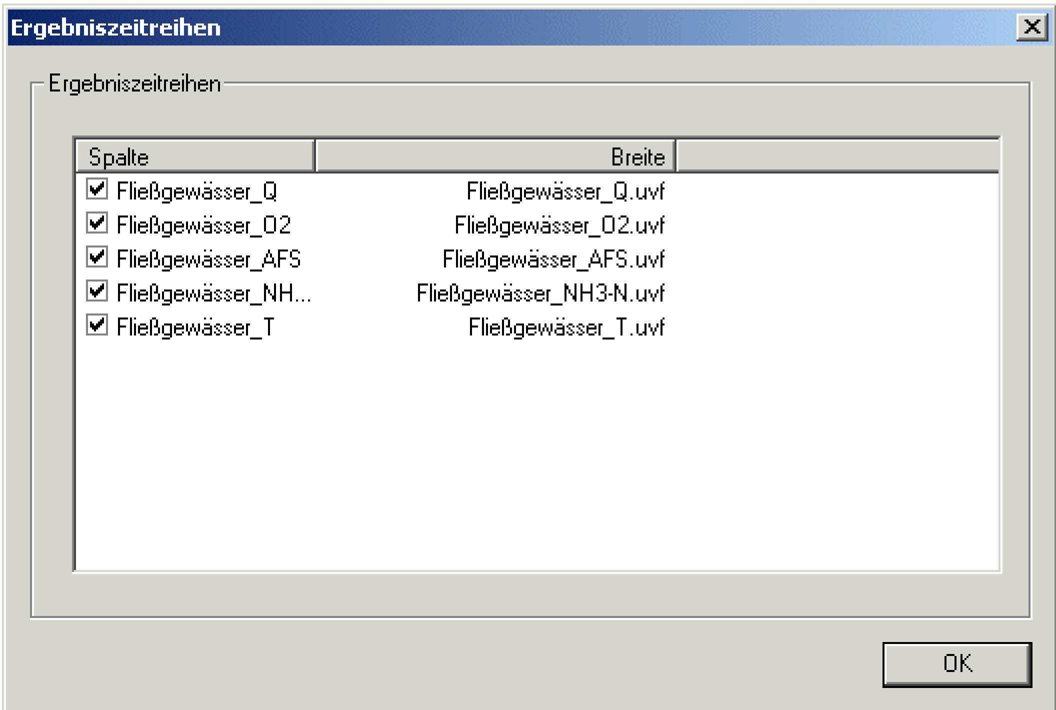


Abbildung 1-140:

1.3.11.3 Outlet

1.3.11.4 WWTP

1.3.12 Abflussganglinien

Neue Abflussganglinien können mit der hier abgebildeten Symbolschaltfläche, über den Menüpunkt „Neu hinzufügen“ im Pulldown-Menü „Systemelemente“ sowie über das Kontextmenü (rechte Maustaste) angelegt werden.
Nach Eingabe der Bezeichnung muss in der Karteikarte „Ganglinienausgabe“ eine Datei angegeben werden (Schaltfläche „Durchsuchen“). Während der Durchführung der Langzeitsimulation werden in diese Datei die berechneten Zuflüsse des „Abflussganglinienobjekts“ geschrieben. Die Datei kann dann zur Darstellung von Abflussganglinien z.B. in das Programm Microsoft Excel eingelesen werden. Das Einlesen von Wasserstandsganglinien, die in STORM© als Zuflüsse zu Entwässerungselementen dienen können, ist in dieser Programmversion nicht realisiert.
Das Abflussziel des Wassers aus dem in der Datei erfassten Entwässerungselement kann in der Karteikarte „Verknüpfung“ ausgewählt werden. Die Angabe des Abflusszieles ist unter Umständen erst durchführbar, wenn alle Entwässerungselemente erfasst worden sind.

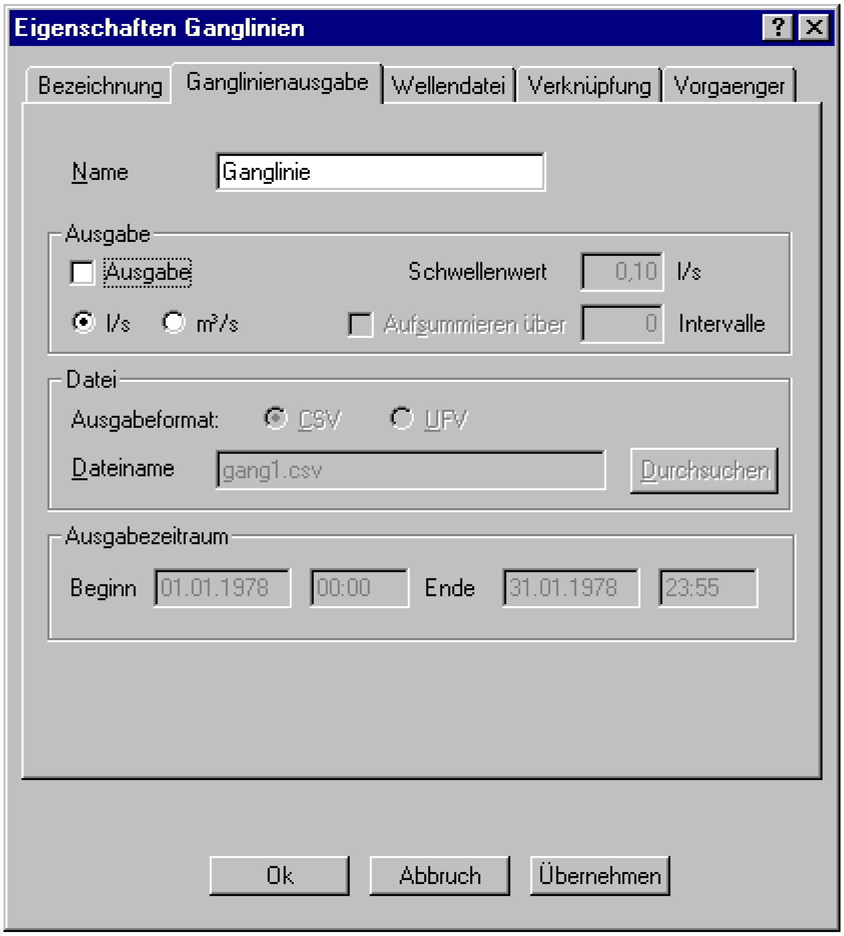
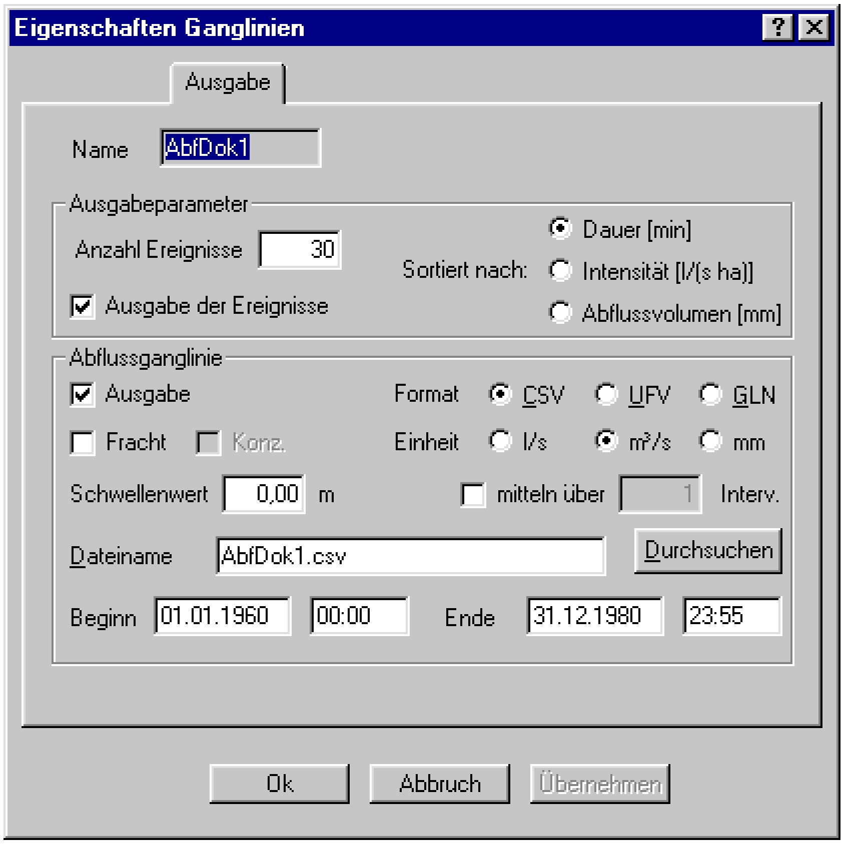


Abbildung 3-47: Erfassung des Dateinamens und des Ausgabezeitraums für eine Abflussganglinie

Zusätzlich kann in der Karteikarte „Wellendatei“ eine Wellendatei zur Übergabe einer Abflussganglinie an das Programm HYSTEM-EXTRAN (itwh) erstellt werden. Hier wird als Anschlussziel der Schacht in der entsprechenden HYSTEM-EXTRAN- Datei angegeben.

1.3.12.1 Runoff Hydrographs: Output Properties



In the properties dialog for the system element "Runoff Hydrographs" you'll find an "Output" tab.

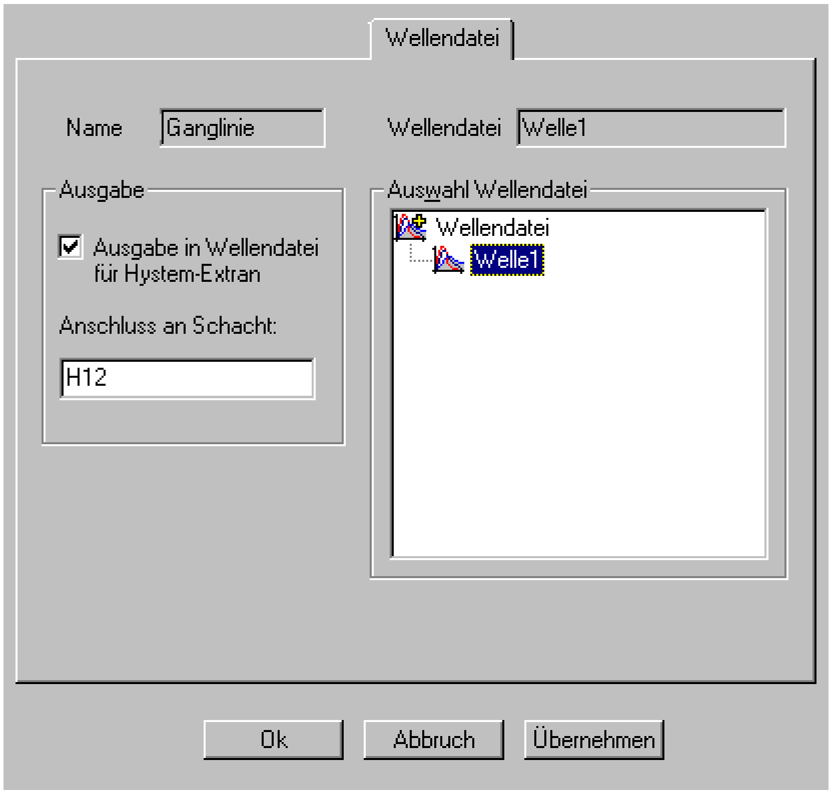
Here you can set the type and scope of the output.

Output
In the "Runoff Hydrograph" section, you can activate the output of the runoff hydrograph by clicking the "Output" checkbox. You can further select whether the output should be in **l/s**, **m³/s**, or **mm**.
When inputting the threshold value, you can suppress the output of zero-values, i.e. periods without water runoff, by entereing the lowest value to be registered. For example, you can enter 0.1 in order to have all events with runoff greater than 0.1 l/s written in the file.
By clicking on the "Average over ... interv." checkbox, you can set whether the values should be summed up over a certain time frame. This is sensible whenever the wavefile should be created over a long period of time since otherwise, the output file will be very large.

File
Enter a filename for outputting the .csv file (values with commas as separators) or select the location and name of the output with the "Browse" button.

Output Period
The timestep for outputting the file can be set in the last row of the tab by entereing the begin and end time. Be aware that the file can become very large.

1.3.12.2 Runoff Hydrographs: Wavefile Properties



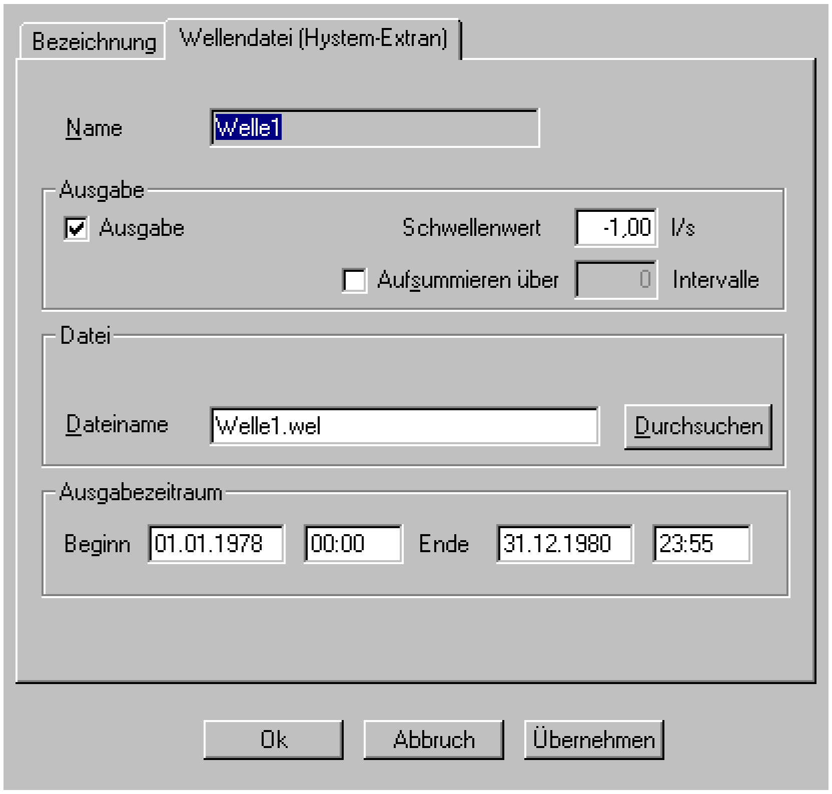
In the properties dialog for the "Runoff Hydrographs" system element, you'll find the "Wavefile" tab.
Here you can set the destination shaft for the output to wavefile (*.wel), which can be integrated by Hystem-Extran for hydrodynamic sewer simulation. For this you must have previously created a wavefile element.

Output
In the "Output" section you can activate output for a hydrograph to a wavefile by clicking the checkbox.
By filling out the "Connection to shaft" field you can define the shaft with which the wavefile is integrated by ***Hystem-Extran (itwh)***.

Choose Wavefile
Here you select the wavefile to which the hydrograph should be output.

1.3.13 External Inflow

1.3.14 Wavefile



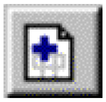
In the properties dialog for a "Wavefile" you'll find the "Wavefile (Hystem-Extran) tab. With this wavefile, you get a connection to the sewer system programme Hystem-Extran (itwh). This can be read with any section of sewer you choose. (see also: Hydrographs) Here you can set the type and scope of the output.

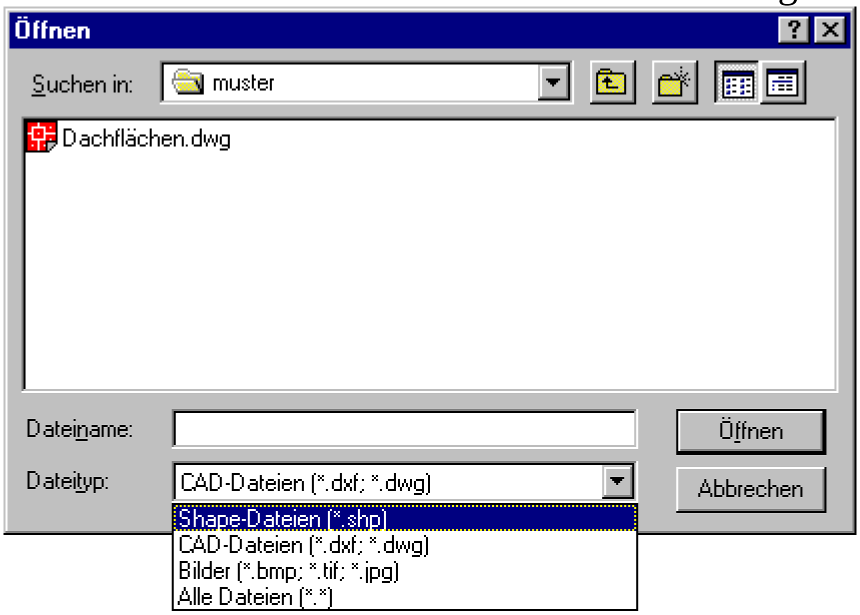
Output
In the "Output" section you can activate output to a wavefile ba clicking on the checkbox.
By inputting the threshold value you can suppress the output of zero-values, i.e. periods without water runoff, by entering the lowest value that should be registered. For example, you can enter 0.1 in order to have all events with runoff greater than 0.1 l/s written to the file.
By clicking on the "Sum up over ... intervals" checkbox, you can set whether the values should be summed up over an indicated period of time. This is sensible whenever the wavefile should be created over a long time frame because otherwise the output file can be very large.

File
Enter a filename for outputting the .csv file (values with commas as separators) or set the location and name of the output with the "Browse" button.

Output Period
The timestep for outputting the file can be set in the last row by filling out the begin and end times. Be aware that the file can become very large.

1.3.15 Layers

 In the "Open" dialog you can add so-called layers. These are external pictures and graphics that can be layered into the programme with accurate coordinates. This button is a shortcut for handling with a mouse.



You can select from the following formats:
.dwg, .dxf AutoCAD and more
.shp Shape-Files
.bmp, .tif, .jpg Pixel graphics, Aerial photos, Graphics files

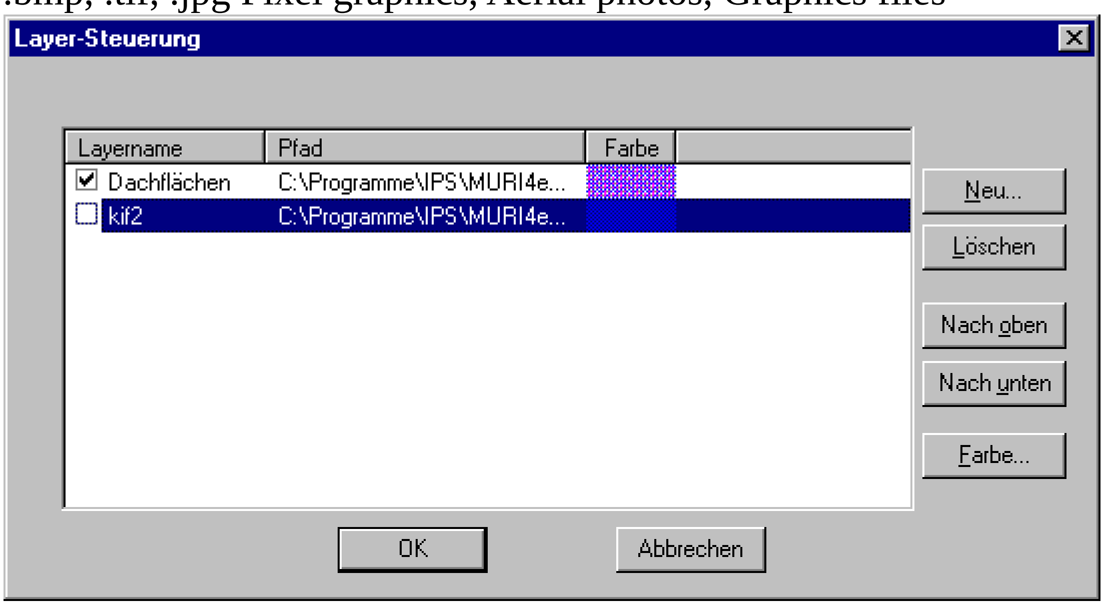


Figure 3-48: "Layer Setup" dialog

In the "Layer Setup" dialog you can select, integrate and add layers with their correct coordinates. You can change the display order and the layer's color. You can also delete an integrated layer.

Layers Overview

The integrated layers are shown in the large window. The layer name, programme path and color are indicataed. The type indicates whether you're dealing with a .shp file, a .dwg file, or a bitmap.

Editing a Layer

New...

The "Open Layer" dialog is called up by clicking on "New..."

Delete
A selected layer is deleted by clicking on the "Delete" button.

Up
By clicking on the "Up" button, the selected layer is moved towards the top of the list so that it is displayed in front of the layers that succeed it.

Down
By clicking on the "Down" button, the selected layer is moved towards the bottom of the list so that it is displayed behind the layers that precede it.
Style...
By clicking the "Style..." button, you can select a color and assign it to a layer.

Tips for Using Raster Graphics

Using the dialogs "Open Layer" and "Layer Setup" you can, among other things, add raster graphics to the system graphic. For this, the following raster formats are supported:

- bmp: Windows bitmap
- tif: Tagged Image File Format
- jpg: JPEG Files

These raster graphics are pure pixel files and are saved without further information about a system of coordinates. That means that each graphic has its origin at 0,0. The coordinates of the upper right point of the graphic conform to the size of the graphic.

With the .tif format, there is the possibility to transform the pixels with a control file to another coordinate system. This file must be saved in the same folder as the graphic and, depending on the type of file, must have the following extention:

- bmp: *bpw*
- jpg: *jgw*
- tif: *tfw*

This control file is read automatically. It must contain the following information for the coordinate transformation:
$x' = Ax + By + C$
$y' = Dx + Ey + F$

where:

x' = computed X-coordinate for the pixel in the system of coordinates y' = computed Y-coordinate for the pixel in the system of coordinates x = pixel's column number in the raster graphic y = pixel's line number in the raster graphic A = scale of the system of coordinates in the X-direction, i.e. pixel's dimension in x-coordinates B,D= Rotation terms, not supported in this version and therefore set to 0.0

E = scale of the system of coordinates in the Y-direction, i.e. pixel's dimension in y-coordinates C = origin of the upper left pixel in x-coordinates F = origin of the upper left pixel in y-coordinates
The values must be saved in the control file in ASCII format (text file) in the following order:
A, D, B, E, C, F

An example:

0.65 A
0.000000 D
0.000000 B
-0.65 E
-281.000000 C

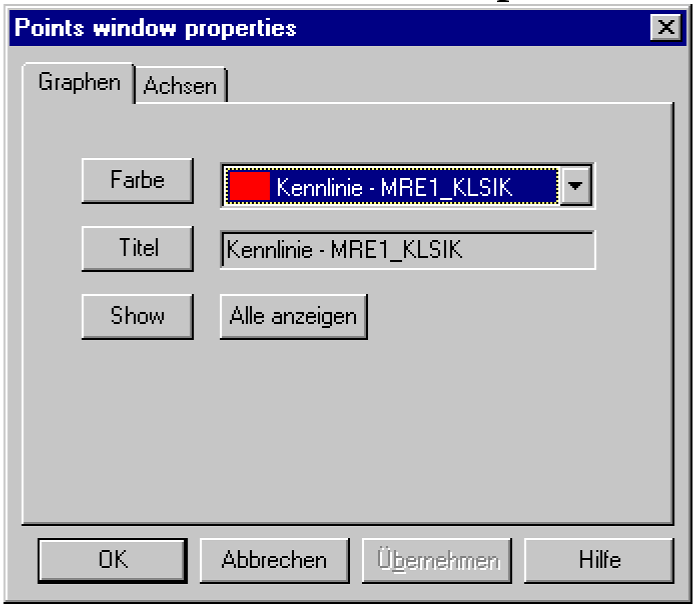
190.000000 F

The letters A-F here are only to explain the order and do not appear in the file!

Layer Style (Layer Setup Dialog)

In this dialog you can assign the layer a foreground and background color as well as an individual cross-hatch pattern.

Characteristic Curves: Properties Dialog

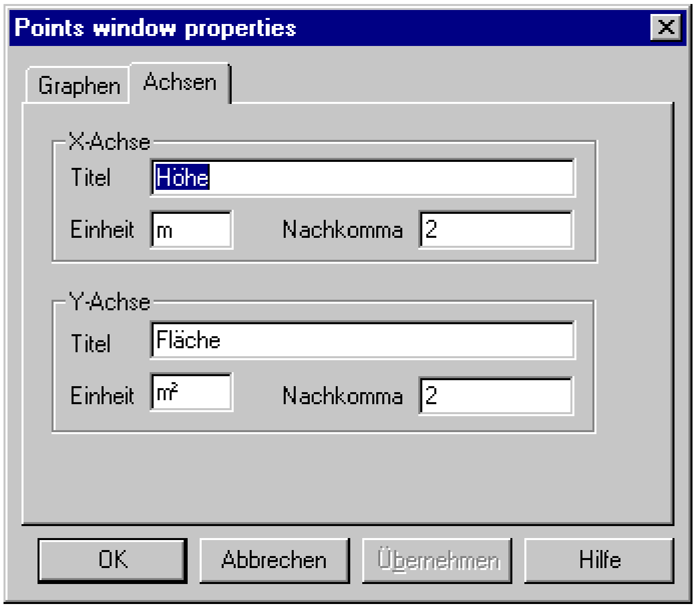


In the "Graphs" tab you can manually adjust the graph for a curve.

Color
Set the color of the graph.

Title
Set the name of the curve.
Show/Hide
Decide whether the graph should be shown or not.

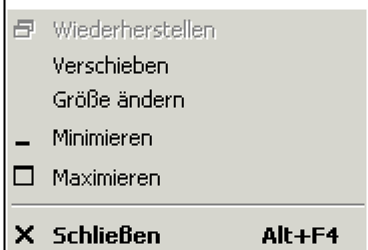
Show all
Shows all graphs.



In the "Axes" tab you can manually adjust the axes for a curve.
You can indicate the name of the axis, the units, and the number of decimal places.

1.4.1 The System Menu

Das Systemmenü erreichen Sie durch einen Rechtsklick mit der Maus auf die Titelleiste oder durch die Tastenkombination ALT + LEERTASTE

<table>
<tr>
<td>
</td>
<td>Das Systemmenü bietet Ihnen unterschiedliche Möglichkeiten das Programmfenster zu verändern:
• Sie können die Position des Fensters auf dem Bildschirm verändern
• Sie können die Grösse des Fensters ändern
• Sie können das Programmfenster in die Taskleiste minimieren
• Sie können das Programmfenster zum Vollbild maximieren
• Sie können das Programmfenster schliessen</td>
</tr>
</table>

Je nach aktuellem Format des Fensters sind unterschiedliche Optionen im Systemmenü anwählbar.

Verschieben

Verwenden Sie diesen Befehl, um einen Vierfachpfeil anzeigen zu lassen, mit dem Sie das aktive Fenster oder Dialogfeld durch Drücken der RICHTUNGSTASTEN verschieben können.

Hinweis: Dieser Befehl ist nicht verfügbar, wenn das Fenster als Vollbild dargestellt wird.

Abkürzung

Tastatur: STRG+F7

Größe ändern

Verwenden Sie diesen Befehl, um einen Vierfachpfeil anzeigen zu lassen, mit dem Sie die Größe des aktiven Fensters durch Drücken der RICHTUNGSTASTEN ändern können.

Nachdem der Zeiger zum Vierfachpfeil geworden ist:

- Drücken Sie eine der RICHTUNGSTASTEN (eine der Tasten NACH-LINKS, NACH-RECHTS, NACH-OBEN oder NACH-UNTEN), um den Zeiger zu dem Rand zu bewegen, den Sie verschieben möchten.
- Drücken Sie eine RICHTUNGSTASTE, um den Rahmen zu bewegen.
- Drücken Sie die EINGABETASTE, wenn die Fenstergröße Ihren Wünschen entspricht.

Hinweis: Dieser Befehl ist nicht verfügbar, wenn das Fenster als Vollbild dargestellt wird.

Abkürzung

Maus: Ziehen Sie die Größenänderungsleisten an den Ecken oder an den Rändern des Fensters.

Minimieren

Verwenden Sie diesen Befehl zur Verkleinerung des Programmfensters zu einem Symbol.

Abkürzungen

Maus: Klicken Sie auf die Schaltfläche für Minimieren  in der Titelleiste.

Tastatur: ALT+F9

Maximieren

Verwenden Sie diesen Befehl zur Vergrößerung des aktiven Fensters, so daß es den gesamten verfügbaren Platz einnimmt.

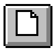
Abkürzungen

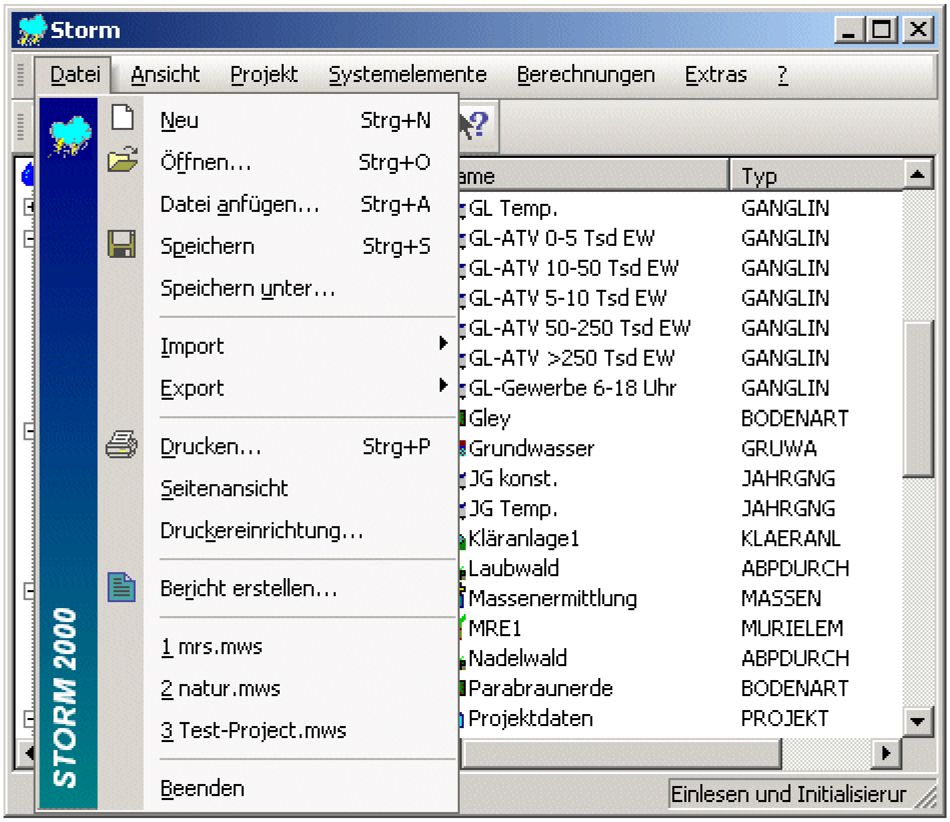
Maus: Klicken Sie auf die Schaltfläche für Maximieren  in der Titelleiste, oder doppelklicken Sie auf die Titelleiste.

Tastatur: STRG+F10 vergrößert ein Dokumentfenster.

1.4.2 Menü Datei

1.2.4.10 File Management

 In the "File" pulldown menu are functions for creating a new file (toolbar button "New"), opening an existing file, and saving files.



The shortcuts for creating, opening and saving files correspond to the standard key combinations used in other windows programmes. You should periodically save your data with Ctrl-S when operating TRINTSIM!

Figure 2-7: The File Menu with commands for managing files

 By clicking this toolbar button, the "Open" dialog window appears to select a file to be read by TRINTSIM. Additionally, the dialog enables selection of different drives and directories.

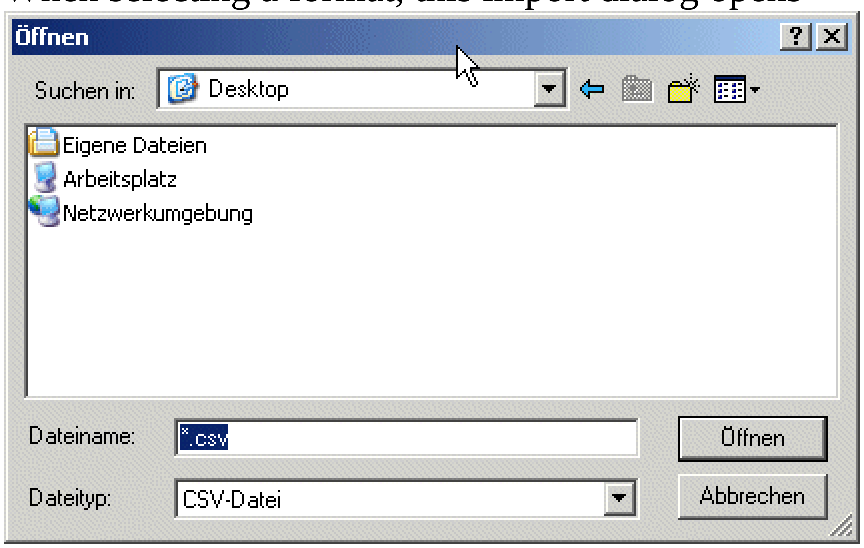
 With this toolbar button, the current file is resaved with any new data. The dialog "Save As" appears if a new file has never been saved.

1.4.2.6 The "Import" Command

With the "Import" command you can load and edit data from other file formats in your STORMę project.
STORMę supports the following formats:

- CSV
- Kosim
- dbase
- MSaccess
- Shapefiles
- Nagis
- Nasim

When selecting a format, this import dialog opens



The following options allow you to select the file to be imported: *Filename*
Enter the filename or select one from the list. In this field, only files with an extension chosen by you in the "File type" field are shown.

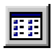
File type
The file type is preset and is the only one supported..

Search in
Select the folder where the file you want to open is saved.

Buttons

 Moves up one folder level.

 Creates a new folder in the current one.

 Shows the icons in list view.

 Shows the icons in detail view.

1.4.2.2.1 Der Befehl Import CSV

Dieser Befehl ermöglicht es Ihnen Dateien im CSV-Format in das aktuelle Projekt einzuladen.

1.4.2.2.2 Der Befehl Import Kosim

Dieser Befehl ermöglicht es Ihnen Dateien aus KOSIM in das aktuelle Projekt einzuladen.

1.4.2.2.3 Der Befehl Import dBase

Dieser Befehl ermöglicht es Ihnen Dateien im dBase-Format in das aktuelle Projekt einzuladen.

1.4.2.6.3 The "Import MS-Access" Command

Export from MS-Access is intended for retransfer of the Storm system data after editing in MS-Access. The stormwater management elements and other data are imported.

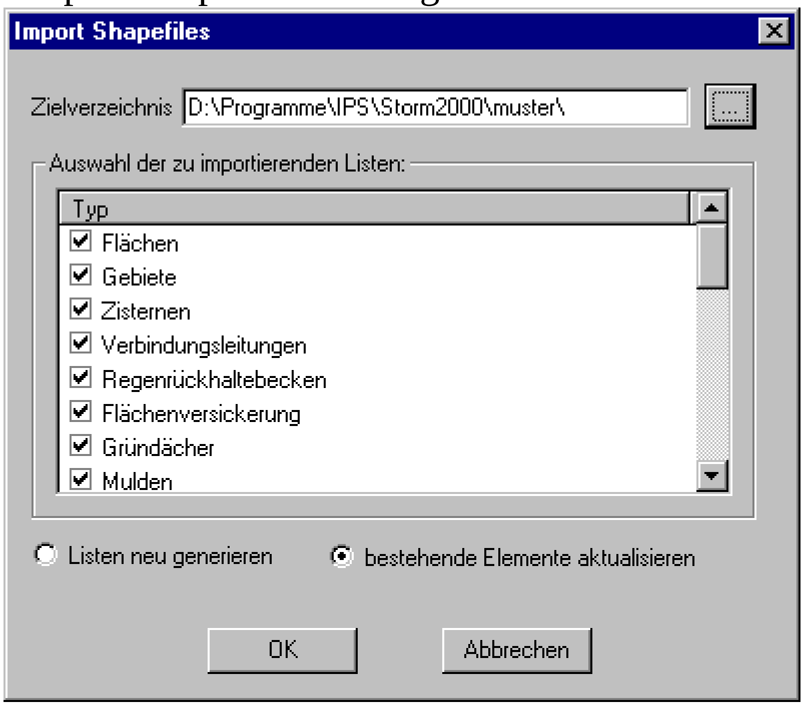
Shortcut

Click on this button: 

1.4.2.6.1 The "Import Shapefiles" Command

Use this command to save drainage elements from shapefiles for further use in the programme and for updating the network.

"Import Shapefiles" Dialog



In the “Import Shapefiles” dialog you can transfer drainage elements as shapefiles from ArcView (Esri). The shapefiles are selected and layered accurate to its coordinates. You can choose whether the lists are newly generated or whether you want to update existing elements.

Dest. Directory
Here you can choose the destination folder of the shapefiles to be imported.

Type
By clicking on the checkboxes to the left of the elements, you can determine which elements should be imported.

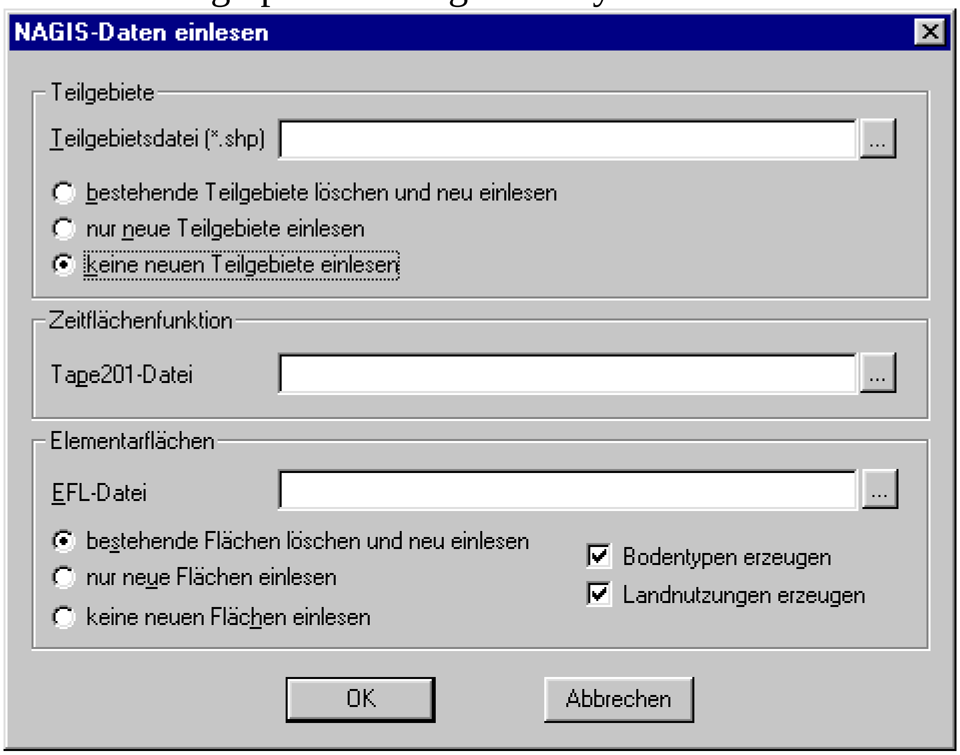
Regenerate Lists or Refresh Elements

By choosing one of the radio-buttons, you can choose whether the lists are regenerated or whether you'd like to refresh exisiting element.

1.4.2.6.5 The "Import NAGIS" Command

You can also arrive at this option by clicking on the following button in the "new natural elements" in the toolbar.

The following options dialog allows you to indicate the file to be opened:



Partial Catchments

In the "Partial Catchments" section you can indicate the partial catchment file to be imported.
In addition, you can determine whether:

- the existing partial catchments should be deleted and then reimported
- only new partial catchments should be imported
- no new partial catchments should be imported

Time Surface Function

In the "Time Surface Function" section you can indicate the Tape201 file to be used

Elementary areas

In the "Elementary Areas" section you can indicate the desired elementary areas file and select between the following options:

- the existing surfaces should be deleted and then reimported
- only new surfaces should be imported
- no new areas should be imported

Additionally, you can determine whether soil types and land usages should be created.

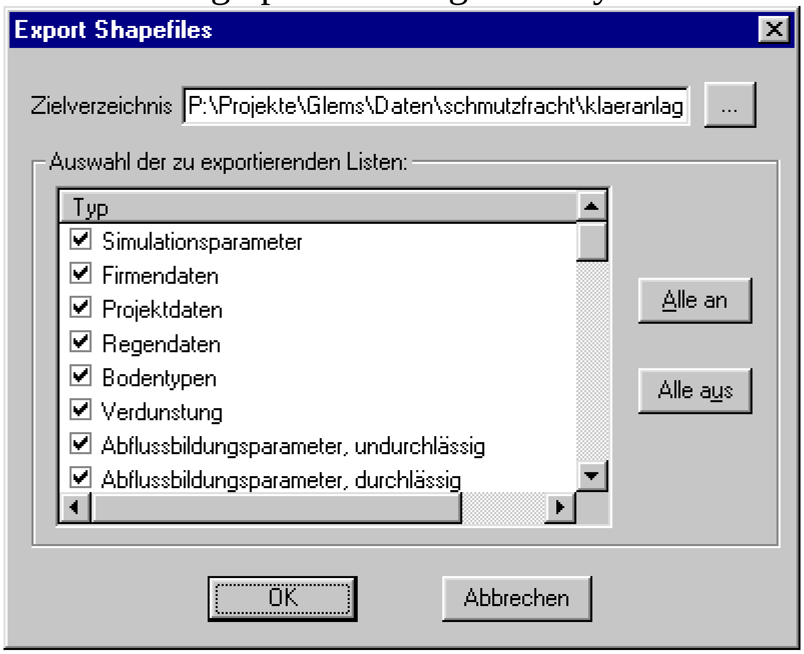
1.4.2.2.7 Der Befehl Import NASIM

Dieser Befehl ermöglicht es Ihnen Dateien aus NASIM in das aktuelle Projekt einzuladen.

1.4.2.7 The "Export" Command

1.4.2.7.1 The "Export Shapefiles" Command

Use this command to save the drainage elements from a file as shapefiles for further use in ArcView.
The following options dialog allows you to indicate the file to be opened:



Dest. Directory
In the "Dest. Directory" section, you can indicate a destination folder.
Choose the Export-Lists
In this section you can select the lists that should be exported. For this, use the checkboxes to the left of the list names.
On the right side of this section you see the "All on" and "All off" buttons. The former selects all lists and the latter deselects all lists.

Shortcit
Mouse: Click on this button:


1.4.2.7.2 The "Export .csv File" Command

Use this command to save a file in .csv format.

1.4.2.7.3 The "Export to MS-Access" Command

Export to MS-Access is intended for editing the storm system data further in MS-Access. The management elements and other data are exported.

1.4.2.11 The "Generate Report" Command

You can start the process of creating a result report by selecting "Generate Report..." in the File Menu.

Viewer

In the “Viewer” section you can see which program will show the created report. This setting can be changed in the "Options" dialog. The "Start Viewer" checkbox determines whether the viewer is automatically opened.

Filename of Report
The name of the created report comes from the name of the current data file and the extension ".rtf" because it's a "Rich-Text-Format" file.

Generate Report
By pressing the "Generate Report" button, the result report is created and, if applicable, the viewer is started.

Options
In the "Options" dialog you set what should be ouput in the report. See also: Report 1 and Report 2 Options

Shortcut

Toolbar: 

1.4.2.11.1 WordView

The reports created by STORMİ in the form of .rtf-files can be viewed and printed out with Microsoft WordViewer97. WordViewer97 is opened by double-clicking on this programme icon.
If the programme WordViewer97 was started by STORMİ as the standard viewer, the report file is automatically converted and shown. If WordView is started at a later point in time by hand, the dialog window shown here is opened automatically. Here you can set the file type to "Rich Text Format (*.rtf)" and choose the desired report file. It is possible that you might have to first select another file folder that contains the .rtf file to be opened.

Figure 3-51: Opening .rtf files with Microsoft WordViewer97

To check the calculation results and the data entered in STORMİ, the document structure can be shown via the "View" pulldown menu in order to be able to switch quickly to a particular subject. If the "Page Layout" view is activated as shown in Figure 3-52, you can browse through the print preview since all pages are shown on the screen as they will be printed later. Printing occurs via the "Print" option in the "File" pulldown menu. In the dialog window that opens, the printer is selected along with the number of pages to be printed (all, current page, or a set of defined pages) and the number of copies to be printed is set as well. If necessary, the printer properties can be changed and you can choose whether you want even or odd pages for double-sided printing.

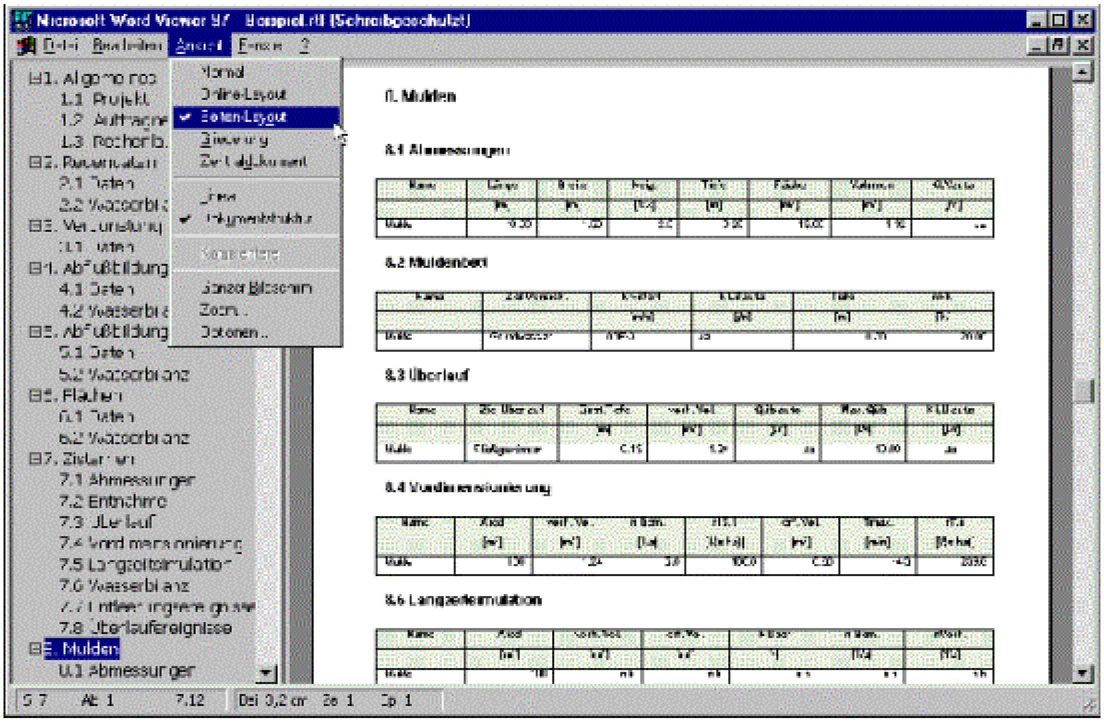


Figure 3-52: Display of the calculation results in WordView

After selecting the entire file with the key combination CTRL-A or by highlighting parts of the results file with the cursor, you can copy the contents to the clipboard with CTRL-C and paste them into other programmes with CTRL-V.

If the function "Open file for editing" in the "File" pulldown menu can be selected, the calculation results can be directly edited further since a text processing programme was found while installing WordViewer that can edit Word files (WordView changes .rtf files to the Microsoft Word format automatically).

1.4.2.11.2 Microsoft Word for Windows

In order to be able later to edit reports created by STORMİ in .rtf format, or to integrate the reports into other text files, you can use any version of Microsoft Word for Windows.
In order for .rtf files to be read by Microsoft Word, you should select "Rich Text Format (*.rtf)" under File Type (see Figure 3-53). When prompted whether the file should be converted, answer yes by clicking "OK".

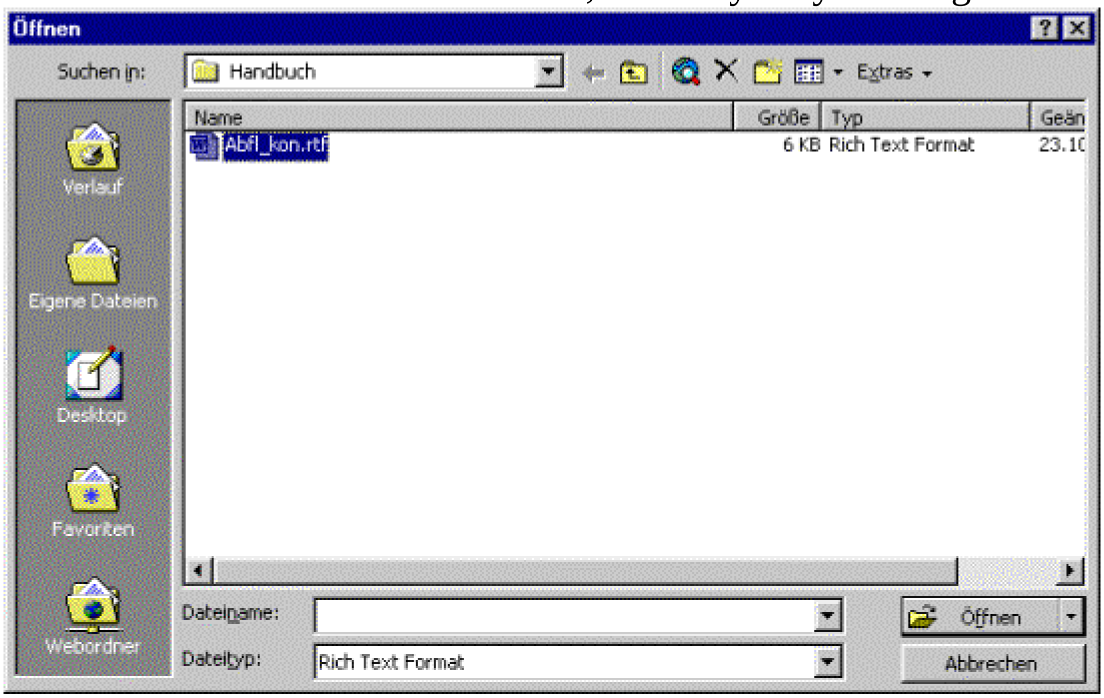


Figure 3-53: Opening an .rtf file with Microsoft Word for Windows

With the "Save As..." option in the "File" pulldown menu, you can resave the report file in the standard Microsoft Word format. To find out more about editing and printing the file, consult the documentation to Microsoft Word.

1.4.2.11.3 Word Processing Programmes by Others

As previously mentioned, any word processing programme able to read .rtf files can be used for outputting the created results report. Here are just a few others:

- Corel Ventura
- Corel WordPerfect
- Lotus Ami Pro or Word Pro
- Sun Stardivision StarWriter

As with the Editor, you should consult the respective programme documentation if you need help opening files in .rtf format.

Additionally, you also have the option to display and print out .rtf files with Microsoft Internet Explorer, Version 3.0 or higher, or with Netscape Navigator, Version 2.0 or higher, as long as you have installed either the Quick View Plus plugin from Inso Corporation or the KeyView plugin from Verity.

1.4.2.11.4 Data Exchange

This version of the programme can read existing files from STORMę Version 2.x and system files in .csv format. To do this, you should use the "Import" option in the "File" pulldown menu, selecting the appropriate file type and selecting the file to be imported in the "Open" dialog window.
There are several possibilites for transfering files from STORMę to other programmes. Using the "Export" function in the "File" pulldown menu, STORMę Elements can be exported in .csv format to a text file for editing with Microsoft Excel and other spreadsheet programmes. Exporting to dBase format for application in various database programmes is planned.
The content of the data table can be copied to the windows clipboard in order to use the data as a table in another programme (such as Microsoft Excel).
Additionally, as explained in the previous section, report files can be read by word processing programmes and the data contained in them can be prepared and transfered to any number of other programmes.

1.4.2.6 Der Befehl Crystal Report erstellen

Mit dem neu integrierten Modul Crystal Reports ist es nun möglich Berichte und Zusammenfassungen so anzulegen, dass alle Informationen zu einem Element nacheinander ausgegeben werden.

Die Ausgabe erfolgt also nach Elementen und nicht wie beim normalen Bericht nach Elementeigenschaften.

1.4.2.10 The "Print Settings" Command

Use this command to designate a printer and printer connection. After selecting the command, the dialog field "Printer Settings" appears where you can set the printer and connection.

The "Printer Settings" Dialog Field

With the following options you can set the printer and its connection:

Printer
Select the printer here that you want to use. Choose either the "standard printer" or use the option "special printer" and then select one of the installed printers from the field. To install printers and set up printer connections, use the Windows control panel.

Format
Choose portrait or landscape format.

Paper/Size
Select the size of the paper on which the document should be printed.

Paper/Feed
Many printers have several trays for various types of paper. Select the paper tray here.

Options
Opens a dialog field in which you have additional options specifically for the printer you selected.

Network...
Use this button to assign a drive letter to a connection to a network.

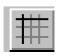
1.4.3 Menü Ansicht

1.4.3.1 The "Table" Command

Use this command to switch to table view mode.

Shortcut

Mouse: Click on this button:

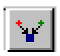


1.4.3.2 The "Graphic" Command

Use this command to swtich to graphic view mode.

Shortcut

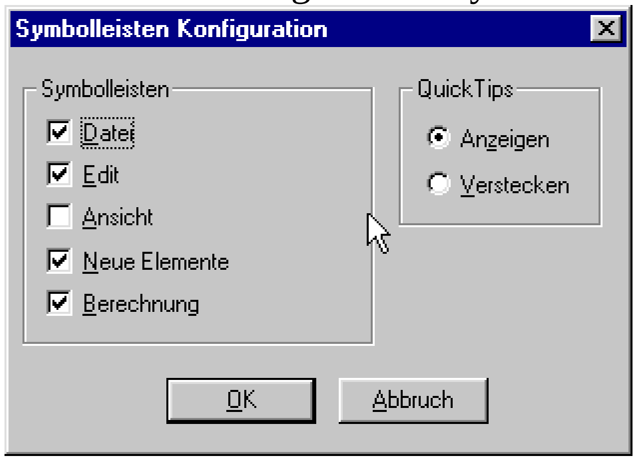
Mouse: Click on this button:



1.4.3.3 Der Befehl Abflussganglinie

1.4.3.3 The "Toolbar" Command

The "Toolbar" command opens the "Toolbars" Dialog in which you can



select from the following options:
Using the checkboxes in the "Toolbars" field, you can select which toolbars should be shown.
In the "QuickTips" field, you can set whether the quick tips are shown with the toolbars or not.

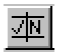
1.4.3.4 The "Status Bar" Command

Use this command to turn the status bar on or off. The status bar describes the action that will occur if you choose a selected menu command or button and shows the status of certain keys. If the status bar is being shown, there is a check next to this command in the "View" pulldown menu.

You can get help using the status bar under Status Bar.

1.4.3.5.1 The Comand "Views" in Table Mode

In the "Views" submenu, you have the following options:

	*Options*	Opens the Options Dialog.
	*Copy Table*	Copies the current table to the clipboard.
	*Paste Table*	Pastes table from the clipboard

1.4.3.5 The Command "Views" (in Graphic Mode)

Options	Opens the options dialog
 Copy Graphic	Copies the current graphic to the clipboard

Layer Setup	Opens the Layer Setup Dialog
Zoom out	Zooms out, makes the graphic smaller
Zoom in	Zooms in, enlarges the graphic
Move	Allows the graphic to be moved around on the screen
Overview	Zooms the graphic so that the whole graphic is visible in the window

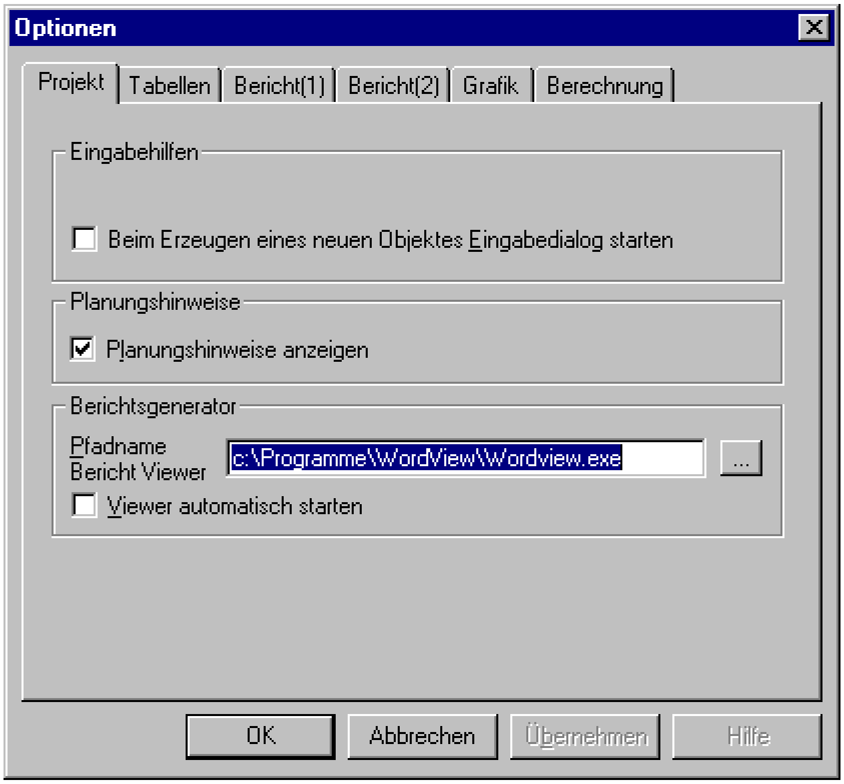
Regenerate Coordinates	Regenerates / updates the coordinates

1.4.4 Menü Projekt

Das Projekt-Menü enthält folgende Befehle:

Firmendaten	Öffnet das Dialogfeld für die Firmendaten.
Projektdaten	Öffnet das Dialogfeld für die Projektdaten.
Simulationsparameter	Öffnet das Dialogfeld für die Simulationsparameter.
Optionen	Öffnet das Dialogfeld für die allgemeinen Programmeinstellungen

1.4.4.3.1 Options: Project Tab



General settings for the programme are set in the "Project" tab in the "Options" dialog.

Input Help
In the "Input Help" section you choose whether an input dialog should be activated when creating a new element.

Planning Tip

In the "Planning Tip" section you choose whether planning tips should be shown while working with elements.

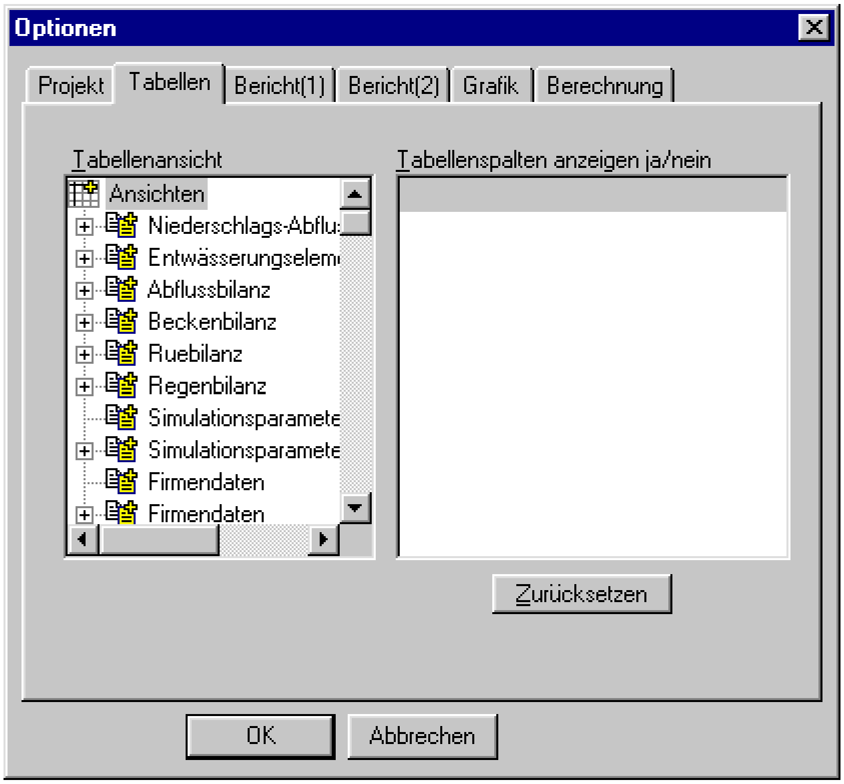
Report Generator

In the "Report Generator" section you choose whether and with which programme the generated report should be displayed.

The default is WordViewer97© by Microsoft. You can, however, use another word processor as a default viewer. The only requirement is that the word processor can read .rtf files.

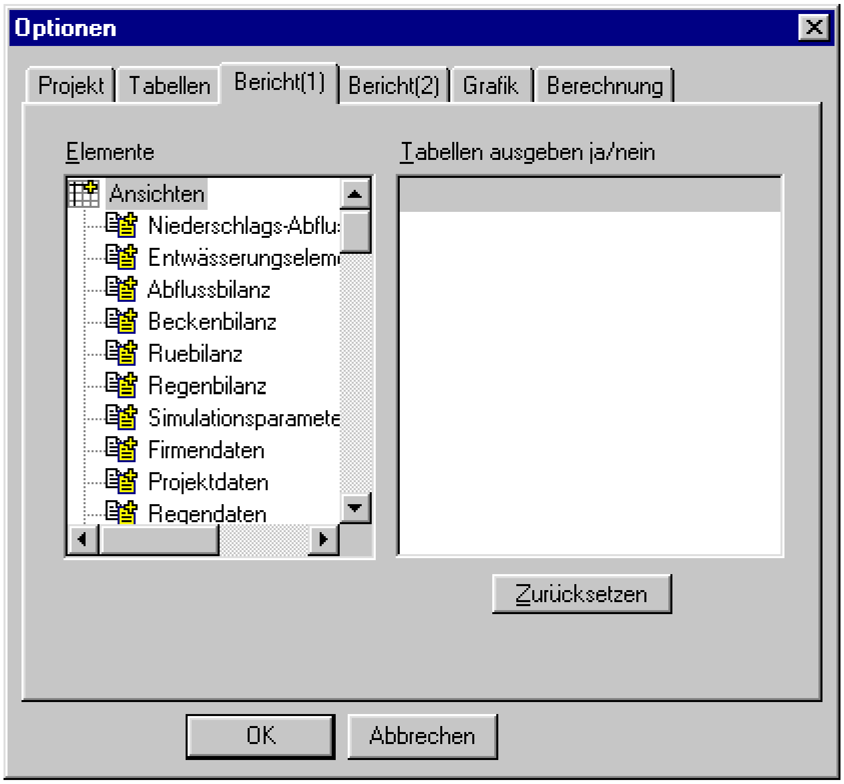
If you prefer, you can also switch the viewer off. The report is then simply saved to the hard drive in .rtf format.

1.4.4.3.2 Options: Tables Tab



In the "Tables" tab in the "Options" dialog, you can set which columns should be shown in each table that is assigned to the drainage elements.

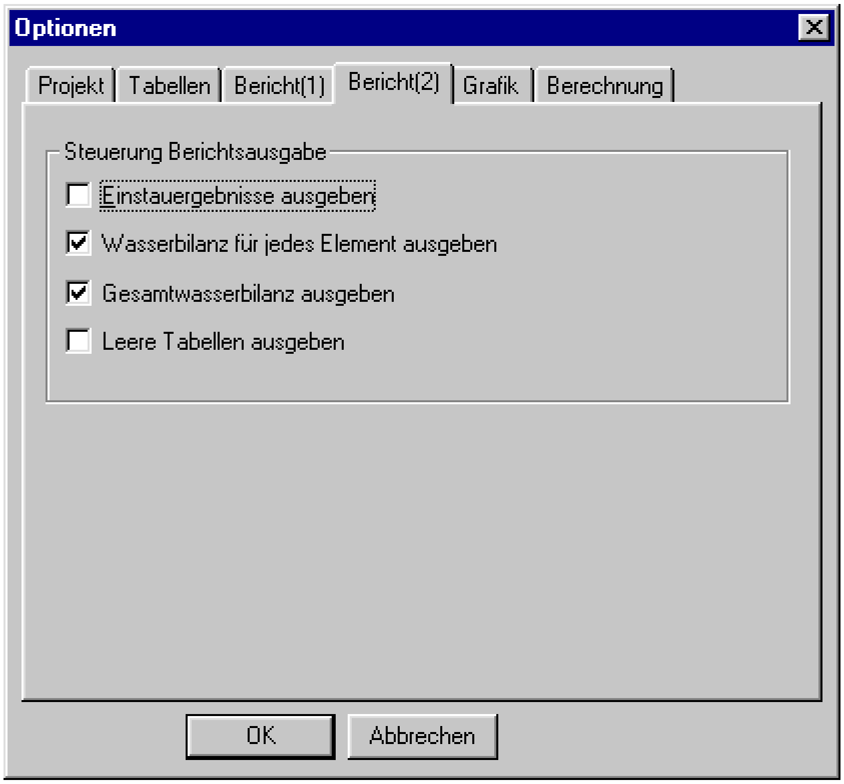
1.4.4.3.3 Options: Report(1) Tab



In the "Report(1)" tab of the "Options" dialog you can set which columns should be output in each table in the report that has been assigned to the drainage elements.

Elements
Click here on the desired element. All available elements are listed here.
Table Output Yes/No
Here you can select the desired columns assigned to the selected element to be output by clicking the checkbox.

1.4.4.3.4 Options: Report(2) Tab



Report Output Setup

In this dialog you can set whether you want to output

- Impound events
- Water balance for each element
- Total water balance
- Empty tables

For this, click on each particular checkbox.

1.4.4.3.5 Options: Graphic Tab

In the "Graphic" tab of the "Options" dialog you determine how the connecting pipes are shown, the zoom factor for the entire display and printout of the screen network.

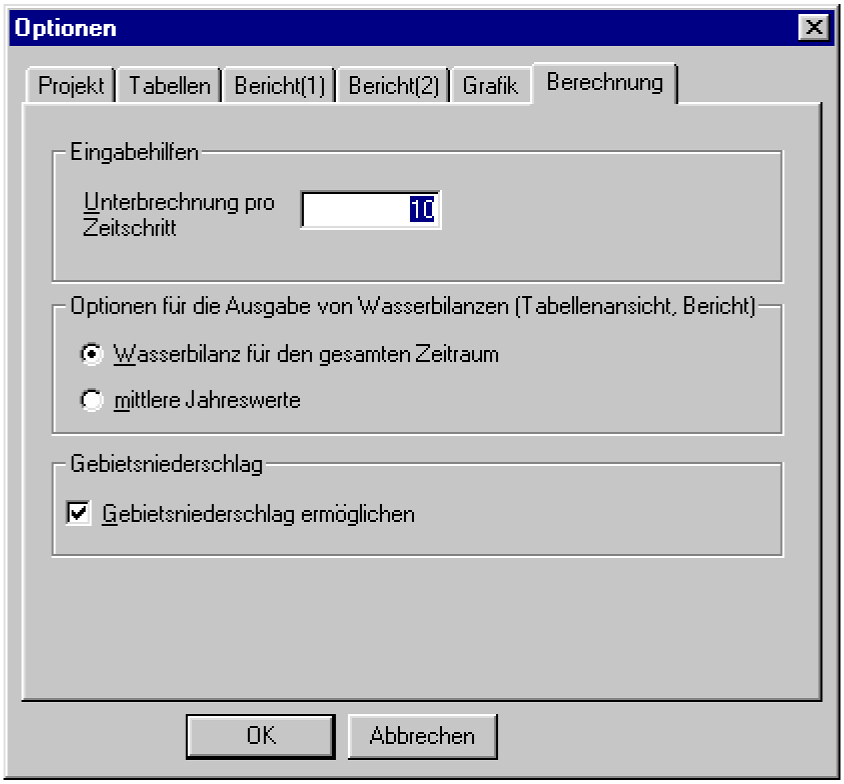
Colors - Connections

By clicking the "Color..." button you can set the color shown for connections, for text and for element icon borders. These settings apply to the whole project.

The colors can be individually set for discharge, infiltration, overflow and treated overflow.

Show Objects
With these checkboxes you set whether surfaces, DW-Objects (Dry Weather), rain gauges and/or Statistic objects should be shown in the graphic.

1.4.4.3.6 Options: Computation Tab



Input Help
In the "Input Help" section you can set how large the interruption should be.

Inputting Infiltration Surfaces

In this section you set whether runoff formation parameters, rain and/or evaporation should be shown.

Water Statistics Options

In this section you can set whether you want to output

- water statistics for the entire time range, or
- average annual values

For this, click on the appropriate button.

Area Precipitation
In this section you can set whether area precipitation should be made possible or not.

1.4.5 Menü Systemelemente

Das Systemelemente-Menü enthält folgende Befehle:

Bemessungsregen	Fügt neuen Bemessungsregen hinzu
Neu hinzufügen	Mit einem Klick auf diesen Menüpunkt können Sie ein einem Untermenü ein entsprechendes Systemelement neu erstellen.
Löschen	Löscht ein ausgewähltes Systemelement.
Duplizieren	Dupliziert ein ausgewähltes Systemelement.
Eigenschaften	Öffnet den Eigenschaftsdialog zu dem ausgewählten Systemelement.

1.4.6 Menü Berechnungen

1.4.6.1 The "Data Check" Command

Use this command to check the existing rain data for correctness.
Shortcut:
Click on this button:

The data check is started by clicking on this button or by selecting "Data Check" in the "Computation" pulldown menu. If everything is in order, you'll receive an on-screen message saying so.
If required inputs are missing in the properties dialogs, you'll receive an error message with more information.

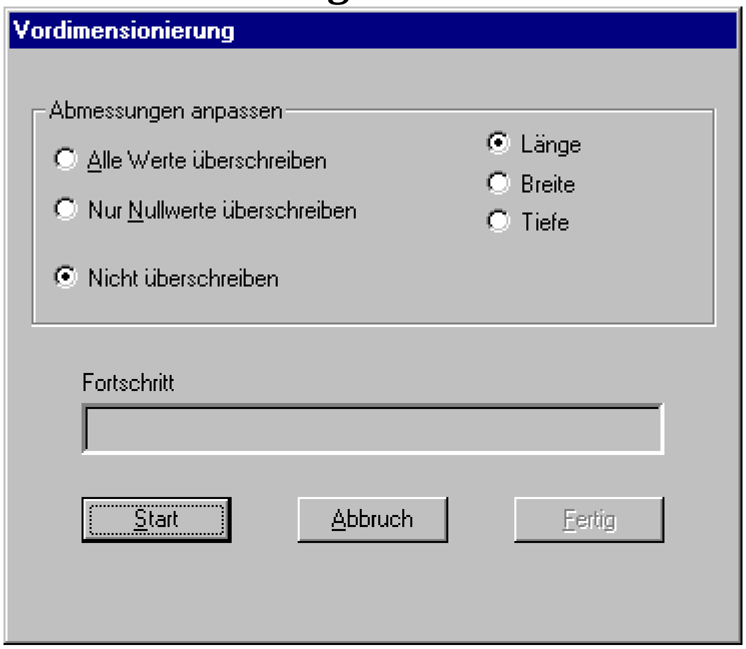
1.4.6.2 The "Delete Computation Results" Command

Use this command to delete the results from pre-dimensioning and long-term simulation.

1.4.6.3 The "Pre-Dimensioning" Command

Use this command to open the dialog for pre-dimensioning.

Pre-Dimensioning



In the "Pre-dimensioning" dialog you can start pre-dimensioning for all system elements.

Fit Dimensions
In the "Fit Dimensions" section, you can set whether you want to fit the original dimensions to the results obtained from pre-dimensioning. You can *overwrite all values* or just *overwrite zero values* or simply select *Do not overwrite*.
Depending on what you select, adjustments are made to dimensions in terms of length, width or hight.

Start
Pre-dimensioning is carried out by clicking on the "Start" button.

1.4.6.4 Pre-Processing

1.4.6.5 Long-Term Simulation

Via the "Long-Term Simulation..." option in the "Computation" pulldown menu or with this button in the toolbar, the dialog window for starting a long-term simulation is opened.
The simulation time frame set in the dialog window "Simulation Parameters Properties" and the time step to be used are shown for checking purposes.
The progress indication and the status bar on the lower right edge of the programme window gives information about the status of the computation after the simulation is started (see Figure 3-49).

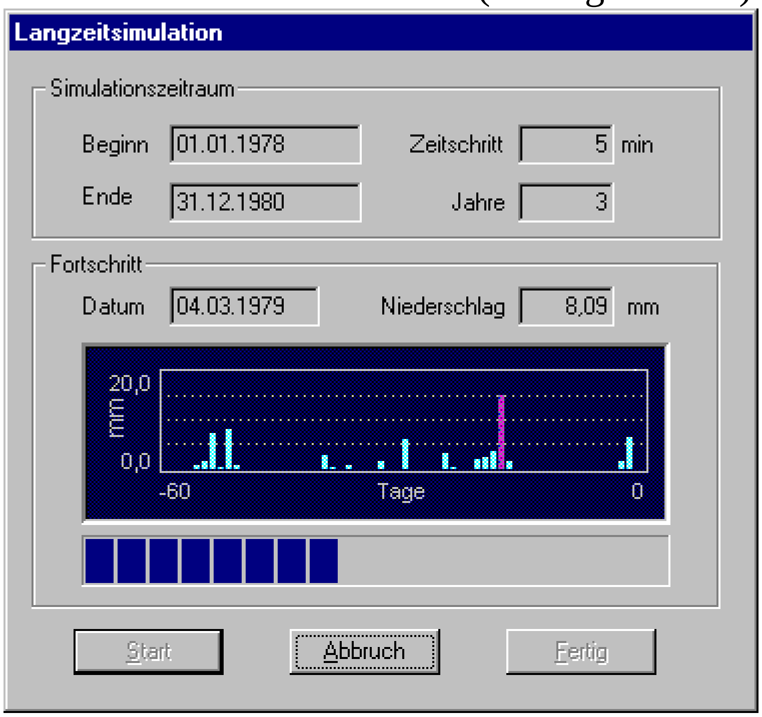


Figure 3-49: Carrying out a long-term simulation

After completing the long-term simultion, the computation results are available for creating a report. the dialog window is closed by clicking the "Finished" button.

1.4.6.6 Area Precipitation

1.4.6.7 Transform Rain Data

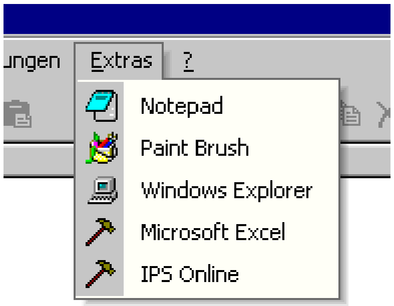
1.4.6.8 Create Design Storm

1.4.6.9 Recalculate Water and Load Statistics

1.4.6.10 Join Legend

1.4.6.11 Show Pre-processing Results

1.4.7 Menü Extras



Im Menü "Extras" sind Verknüpfungen zu individuell einstellbaren Programmen abgelegt.

Über einen Mausklick werden die jeweiligen Programme ausgeführt.

Im Bereich "Extras" des Anpassen Dialoges können Art und Reihenfolge der Programme verändert werden.

1.4.8 Menü Hilfe

1.5.1.1 Scrollbars

The scrollbars are on the right and lower edges of the document window. The scrollboxes within the scrollbars reflect the vertical and horizontal position of your document. You can use the mouse to scroll up or down, left or right through the document.

1.5.1.2 Title Bar

The title bar streches across the upper edge of the window. It contains the name and application of the document.

You can drag the title bar to move the window around on the screen. Tip: You can even move dialog windows by dragging their title bars.

A title bar can contain the following elements:

- The application's system menu button
- The document's system menu button

- The maximise button

- The minimise button

- Name of the application

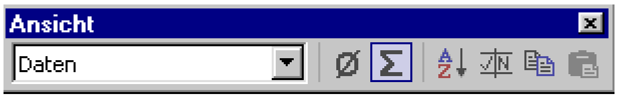
- Name of the document

- The restore button

1.5.1.3 Status Bar

The status bar is shown at the lower edge of the programme window. You can show or hide the status bar in the "View" menu with the "Status Bar" command.
As you move through menus with the ARROW KEYS or with the mouse, the left section of the status bar describes the function of menu options. Likewise, if you move the mouse over a button, the left section of the status bar will describe what that button does.
The right section of the status bar indicates which of the following keys are activated: *Display Description*
CAPS The CAPS LOCK is on
NUM The NUMBER LOCK is on
SCRL The SCROLL LOCK is on

1.5.2 "Table View" Toolbar



This toolbar is shown by default at the top of the programme window underneath the menus when Table View is switched on. You can move it around and place it wherever you like with the mouse.

It offers quick access to the viewing functions for tables:

You can select various table views using the list field. Depending on the selected element, you can show

- Connections

- Water balance statistics

- Dimensions

- Overflow
- Pre-dimensioning
- Long-term simulation

- Impound results

- Swale bed

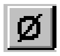
- Infiltration

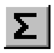
- Throttle

- Removal

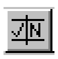
- Hydraulics

Data

 Shows the yearly average vaules for discharges and loads.

 Shows the cumulative values for discharges and loads.

 Sorts the table.

 The Viewing Options dialog is opened.

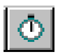
 Copies the table to the clipboard.

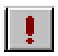
 Pastes a table from the clipboard.

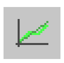
1.5.3 "Simulation" Toolbar

This toolbar is shown by default underneath the menu bar. You can move it around and place it anywhere you like with the mouse.
With one mouseclick, it is possible to carry out a data check, input simulation parameters, or start a long-term simulation: *Click on... in order to...*

 ...carry out a data check.

 ...open the dialog for entering simulation parameters.

 ...open the dialog for executing a long-term simulation.

 ...shows statistical analysis.

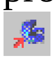
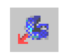
1.5.4 "Export/Import Shapefiles" Toolbar

This toolbar is shown by default underneath the menu bar. You can move it around on the screen with the mouse and place it anywhere you like.
The toolbar makes it possible: 1) either to import shapefiles from ArcView with a mouseclick und export them from the programme: *Click on... in order to...*

 ...*export* drainage elements in *Shapefile format* (ArcView).

 ...*import* drainage elements in *Shapefile format* (ArcView).

2) or to import files in MS-Access format and export them from the programme with a mouseclick: *Click on... in order to...*

 ...e*xport* drainage elements in *MS-Access format*  ...i*mport* drainage elements in *MS-Access format*

1.5.5 "Graphical View" Toolbar

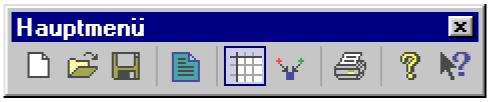
This toolbar is shown by default below the top of the programme window underneath the menu bar whenever graphic view is switched on. You can move it around with the mouse and place it anywhere you like.
The toolbar offers quick access to the viewing functions for the graphic:
Click on... in order to...

 ...zoom in on the graphic.

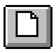
 ...zoom out from the graphic.

 ...copy the graphic to the clipboard.

1.5.6 "Main Menu" Toolbar



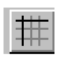
This toolbar is shown be default near the top of the programme window underneath the menu bar. You can move it around with the mouse and place it anywhere you like.
It offers quick access to a few general functions of the application:
Click on... in order to...

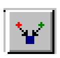
 ...open a new document.

 ...open an existing document. A dialog box opens in which you can search for and open the desired file.

 ...save the document under its current name. If the file has not yet been saved, the "Save as..." Dialog opens.

 ...create a result report in .rtf-format.

 ...switch to table view.

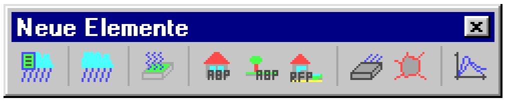
 ...switch to graphic view.

 ...print the active document.

 ...call up the info dialog.

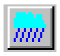
 ...request help with a selected menu option. Click on the button and then click on the option you'd like help with.

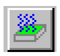
1.5.7 "New Elements" Toolbar



This toolbar is shown by default on the left edge of the programme window.
You can move it around with the mouse and place it anywhere you like.
It makes it possible to create a new desired element with one mouseclick:
Click on... in order to...

 ...input a new design storm.

 ...create a new rain gauge element.

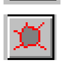
 ...create a new evaporation element

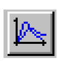
 ...create a new set of runoff formation parameters for impermeable surfaces.

 ...create a new set of runoff formation parameters for permeable surfaces.

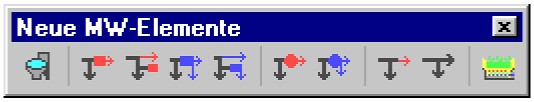
 ...creates a new set of runoff formation parameters for disconnected surfaces.

 ...create a new surface element.

 ...create a new catchment element.

 ...create a new runoff hydrograph element.

1.5.8 "New CSO Elements" Toolbar

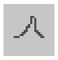
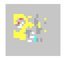
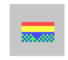


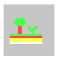
This toolbar is shown by default on the left edge of the programme window.
You can move it around with the mouse and place it anywhere you like.
It makes it possible to create a new desired element with one mouseclick:
Click on... in order to...

 ...add a new dry weather flow element.
 ...add a new retention tank (online).
 ...add a new retention tank (bypass).
 ...add a new throughflow tank (online).
 ...add a new throughflow tank (bypass).
 ...add a new sewer with storage capacity, overlying discharge.
 ...add a new sewer with storage capacity, underlying discharge.
 ...add a new sewer overflow.
 ...add a new branching.
 ...add a new soil filter element.

1.5.8 "New Nature Elements" Toolbar

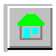
This toolbar is shown by default on the left edge of the programme window.
You can move it around with the mouse and place it anywhere you like.
It makes it possible to create a new desired element with one mouseclick:
Click on... in order to...

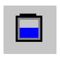
 ...import a new NAGIS file  ...import a new NASIM file  ...add a new soil moisture element.

 ...add new land usage element.

1.5.9 "New Stormwater Elements" Toolbar

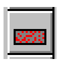
This toolbar is shown by default on the left edge of the programme window.
You can move it around with the mouse and place it wherever you like.
It makes it possible to create a new desired element with one mouseclick:
Click on... in order to...

 ...add a new green roof.

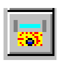
 ...add a new cistern.

 ...add a new surface infiltration.

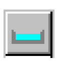
 ...add a new swale.

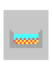
 ...add a new trench.

 ...add a new swale-trench element.

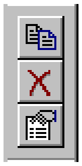
 ...add a new Innodrain element.

 ...add a new connection pipe.

 ...add a new stormwater retention tank.

 ...add a new stormwater sedimentation tank.

1.5.10 "Edit Objects" Toolbar



This toolbar is shown by default at the left edge of the programme window. You can move it around and place it anywhere you like with the mouse. With one mouseclick, you can duplicate or delete an element, or edit its properties: *Click on... in order to...*

 ...duplicate a selected element.

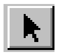
 ...delete a selected element.

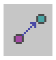
 ...edit a selected element's properties.

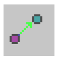
1.5.11 "Shapefile View" Toolbar

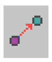
This tool bar is shown by default at the top of the programme window underneath the menus whenever the programme is in graphic-view mode. You can move the toolbar and place it anywhere you like with the mouse. It offers quick access to the viewing functions for the graphic:

Click on... in order to...

 ...select and edit an element.

 ...set a new discharge destination.

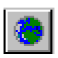
 ...set a new overflow destination.

 ...set a new infiltration destination.

 ...zoom in on the graphic.

 ...zoom out from the graphic.

 ...move the graphic around on the screen.

 ...fit the entire graphic in the window.

 ...add a new layer.

 ...edit a layer's properties.

 ...copy the graphic to the clipboard.

1.5.12 "Page View" Toolbar

In the "Page View" toolbar there are the following options available to you:

Print
You can call up the print dialog, in which you can start a print job.

Next Page
Shows how the next printed page will appear.

Previous Page
Shows how the previous printed page will appear.

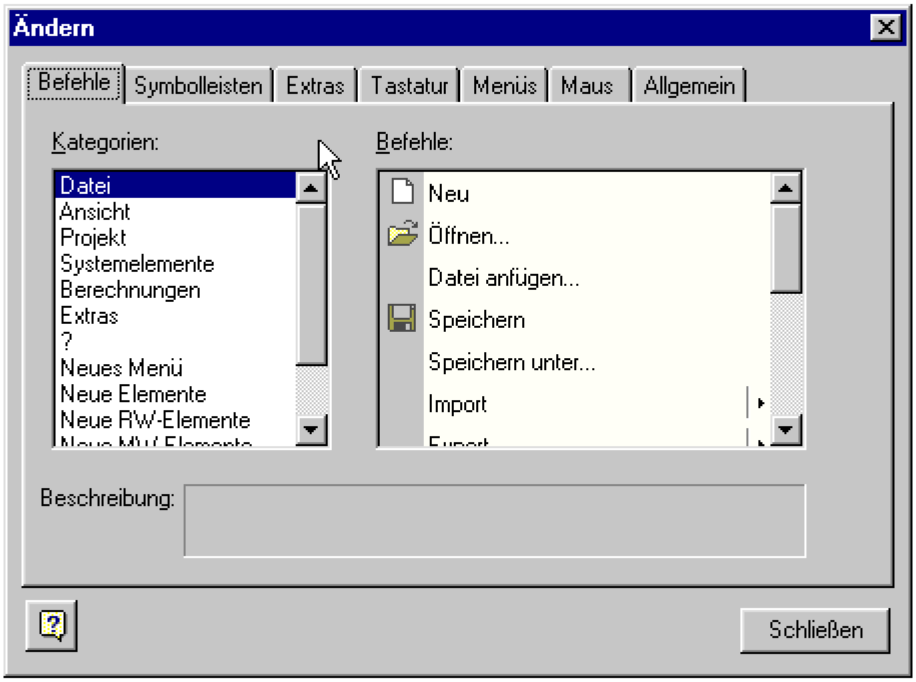
One Page/Two Pages
Determines whether one or two pages are shown at the same time.

Zoom in
Allows you to view the page more closely.

Zoom out
Gives you a larger overview of the printed page.

Close
Closes the page view and returns to the main editing window.

1.5.13 Symbolleisten Konfiguration

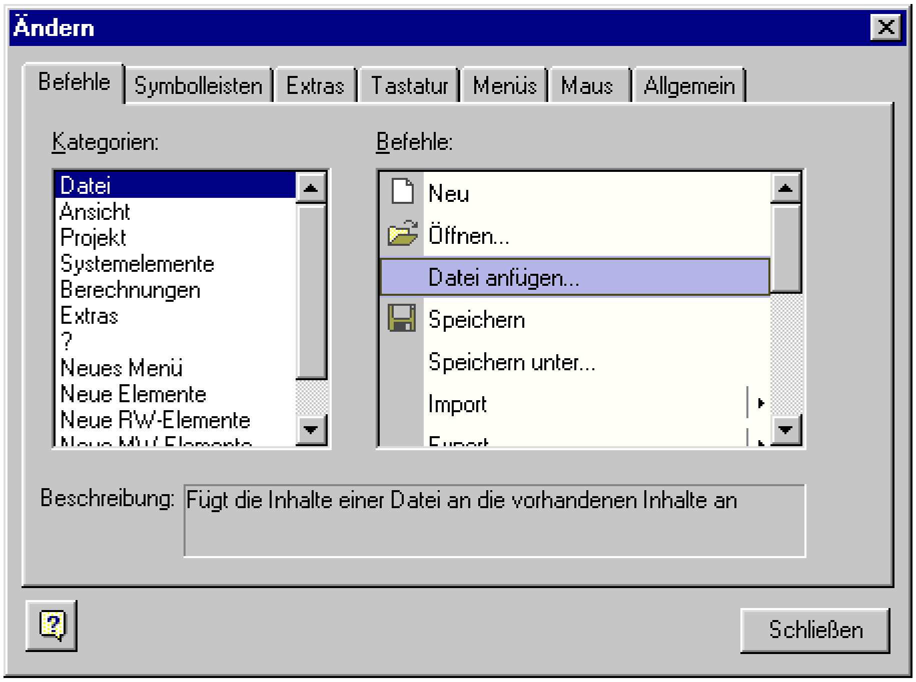


Im Dialog “Ändern" können eingestellt werden:

- Befehle
- Symbolleisten
- Extras
- Tastatur
- Menüs
- Maus
- Allgemein

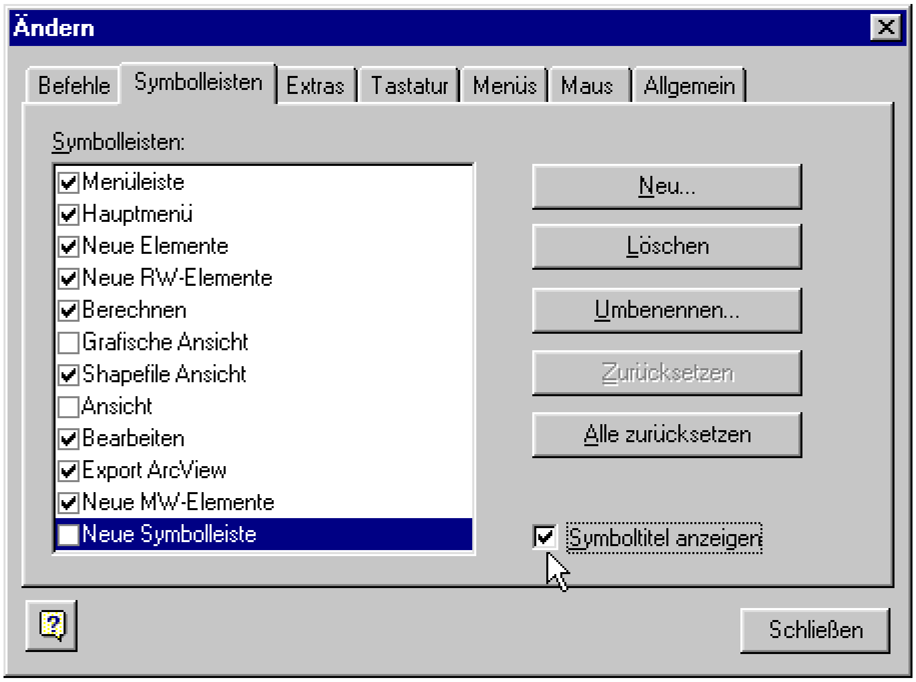
Das Symbol ruft die Hilfe zum aktuellen Dialogfeld auf.

1.5.13.1 Toolbar Configuration: Commands Tab



If you select one of the categories listed in the "Categories" section, the available commands for this category are shown in the "Commands" section. If you activate a command with the mouse, a short description of this command appears below in the "Description" section. You can add any command to any toolbar you wish simply by dragging the command with the mouse and dropping it in that toolbar.

1.5.13.2 Toolbar Configuration: Toolbars Tab



You can see all available toolbars listed in the "Toolbars" section. Using the checkboxes, you can switch each toolbar on or off. There are also the additional following commands:

The "*New...*" button creates a new toolbar with a user-defined name. Commands listed in the "Commands" tab in the same dialog can be assigned with the mouse to the newly created toolbar.

The "*Delete*" button deletes self-created toolbars.

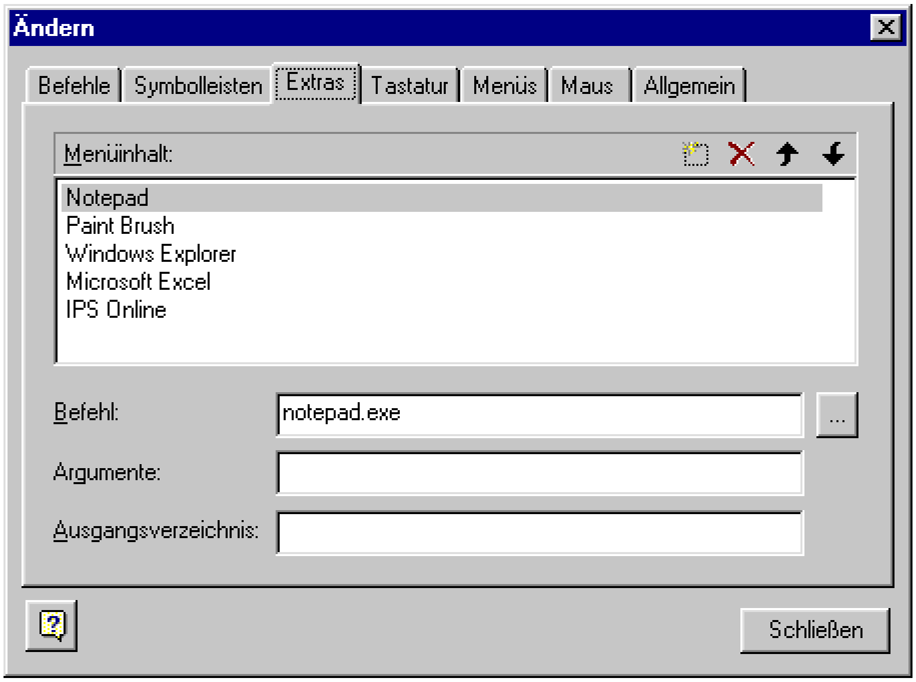
The "*Rename...*" button makes it possible to rename a self-created toolbar.

The "*Reset*" button sets all selected toolbars back to their original default state.

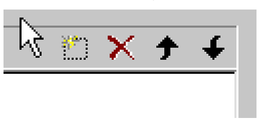
The "*Reset all*" button sets all toolbars back to their original default state.

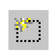
By activating the "Show text labels" checkbox, you can set whether short descriptions for single commands should be shown along with the icons or not.

1.5.13.3 Toolbar Configuration: Extras Tab



In the "Menu contents" section, the contents of the "Extras" pulldown menu are listed. In the upper right corner of the dialog are the following icons:



The commands in the "Menu contents" section:  The "*New*" command creates a new entry.

 The "*Delete*" command deletes a selected entry.

 The "*Move item up*" command moves an entry towards the top.

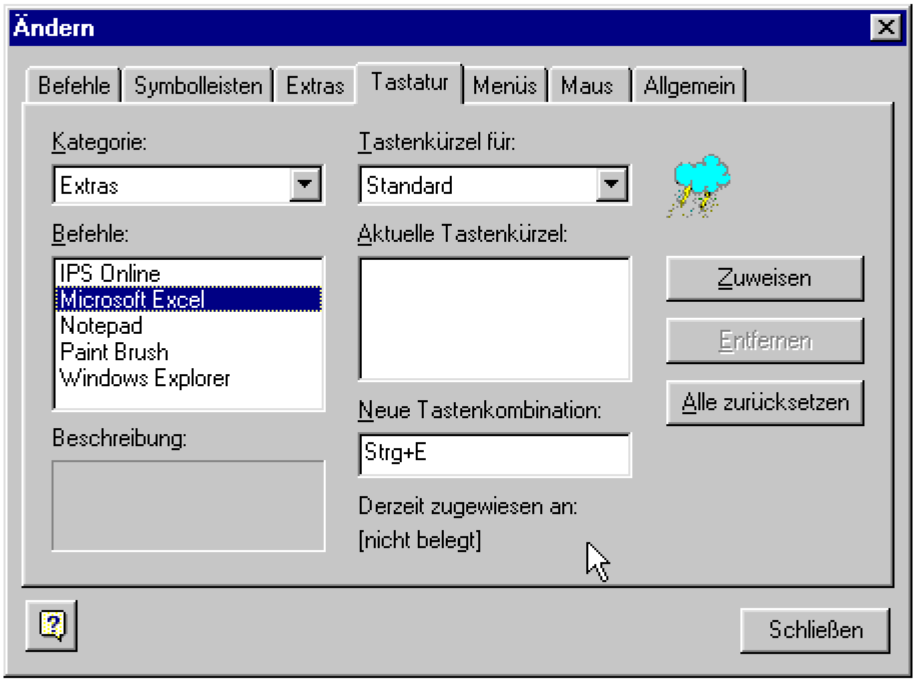
 The "*Move item down*" command moves an entry towrads the bottom.

In the "*Command*" line you can set the file to be executed.

In the "*Arguments*" line you can assign an argument to a selected entry.

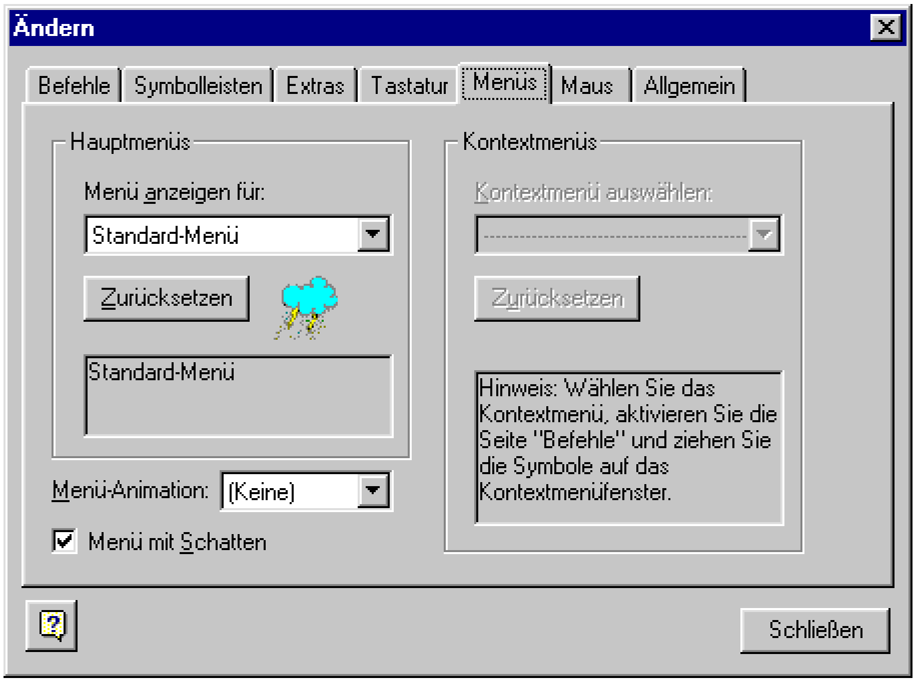
In the "*Initial directory*" line you can set the initial directory.

1.5.13.4 Toolbar Configuration: Keyboard



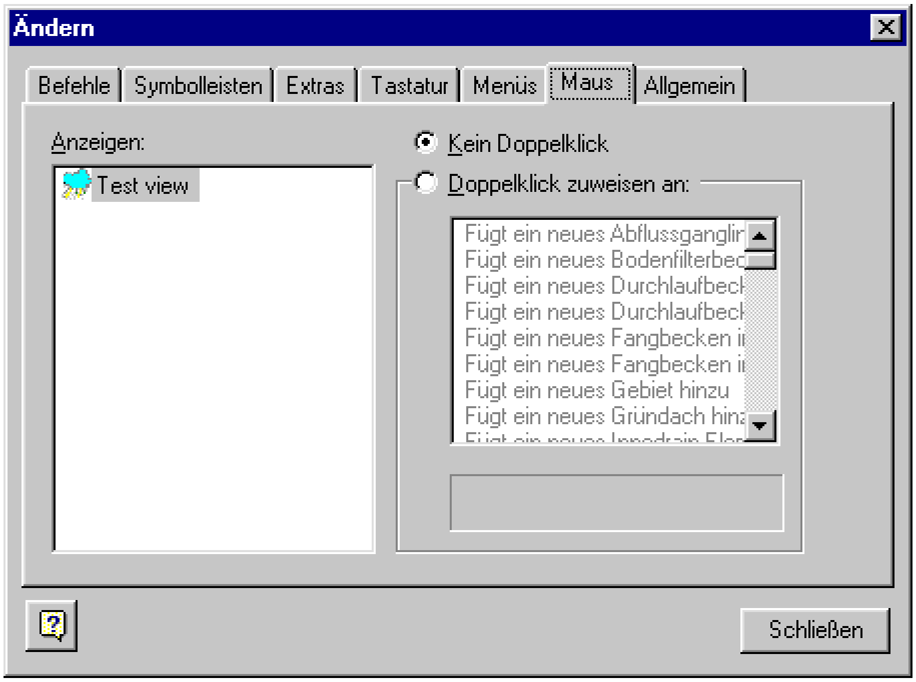
In the "*Category*" section you can select one of the listed categories.
In the "*Commands*" section, all available commands are listed for that category.
In the "*Description*" section, a short description is given for a selected command.
In the "*Shortcut* for"
In the "*Current Shortcut*" section, the current shortcut is shown for the activated command.
In the "*New keystroke*" section, a desired new keystroke combination can be entered for the aktivated command.
Using the "*Assign*" button, the desired new keystroke combination is assigned to the activated command.
Using the "*Remove*" button, the keystroke assignment for the active command is deleted.
Using the "*Reset All*" button, all changes are undone.

1.5.13.5 Toolbar Configuration: Menus

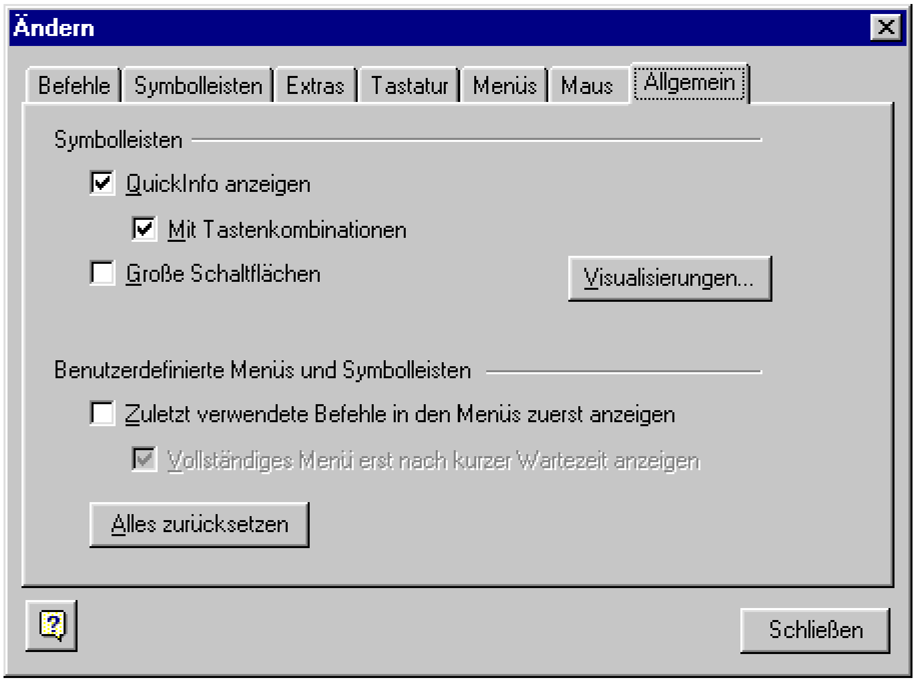


In the "*Application Frame Menus*" section, you can set which menu should be shown when no document is open.
The "*Reset*" button returns the settings to the standard menu.
In the "*Menu animation*" section you can choose one of the preset menu animations. Additionally, you can set whether the menus should be shown with its shadow.
In the "*Context menu*" section

1.5.13.6 Toolbar Configuration: Mouse



1.5.13.7 Toolbar Configuration: Options



Toolbar:

In this section you can set:

- whether QuickTips should be shown
- whether the keystroke combinations should be given in the QuickTips

or

- whether large buttons should be used for the icons.

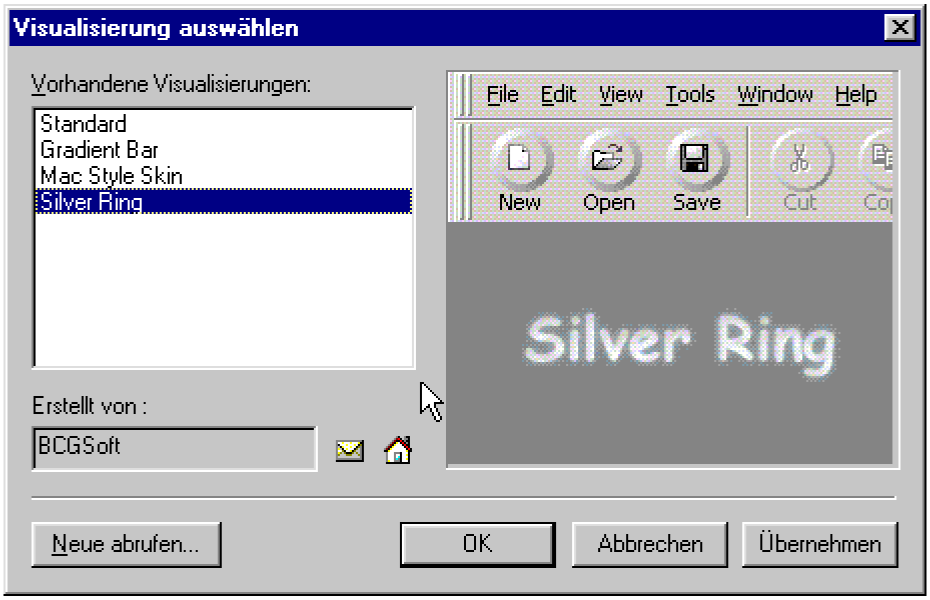
Clicking on the "*Visualisations*" button calls up the Visualisations Dialog.

Personalised menus and toolbars:

In this section you can set whether the commands last used should be shown first in the menus or not, and whether the complete menus should be shown only after a short wait or not.

The "Reset Usage Data" button erases all data about which commands you have last used.

1.5.13.8 Toolbar Configuration: Visualisation



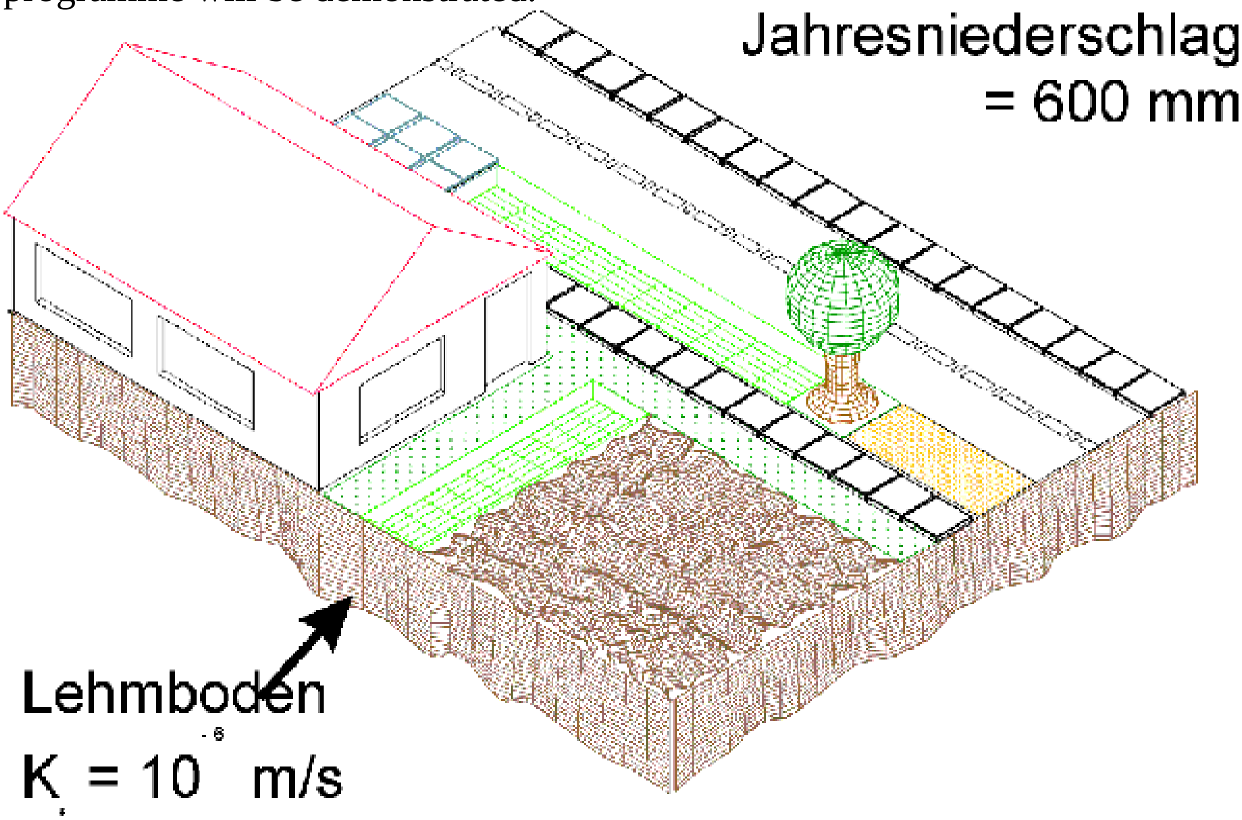
In the "*Available Visualisations*" section, all available layouts are listed. You can select one by clicking with the mouse. Then, a preview of the layout is shown in the left frame and the creator of the layout is shown in the text field "*Created by*".

Using the "*Download...*" button you can download new visualisations from the internet.

2.1 Demonstration of a Sample Project

Planning Project

We would like to briefly present you the following example for a project here. As many elements as possible that you can dimension with this programme will be demonstrated.

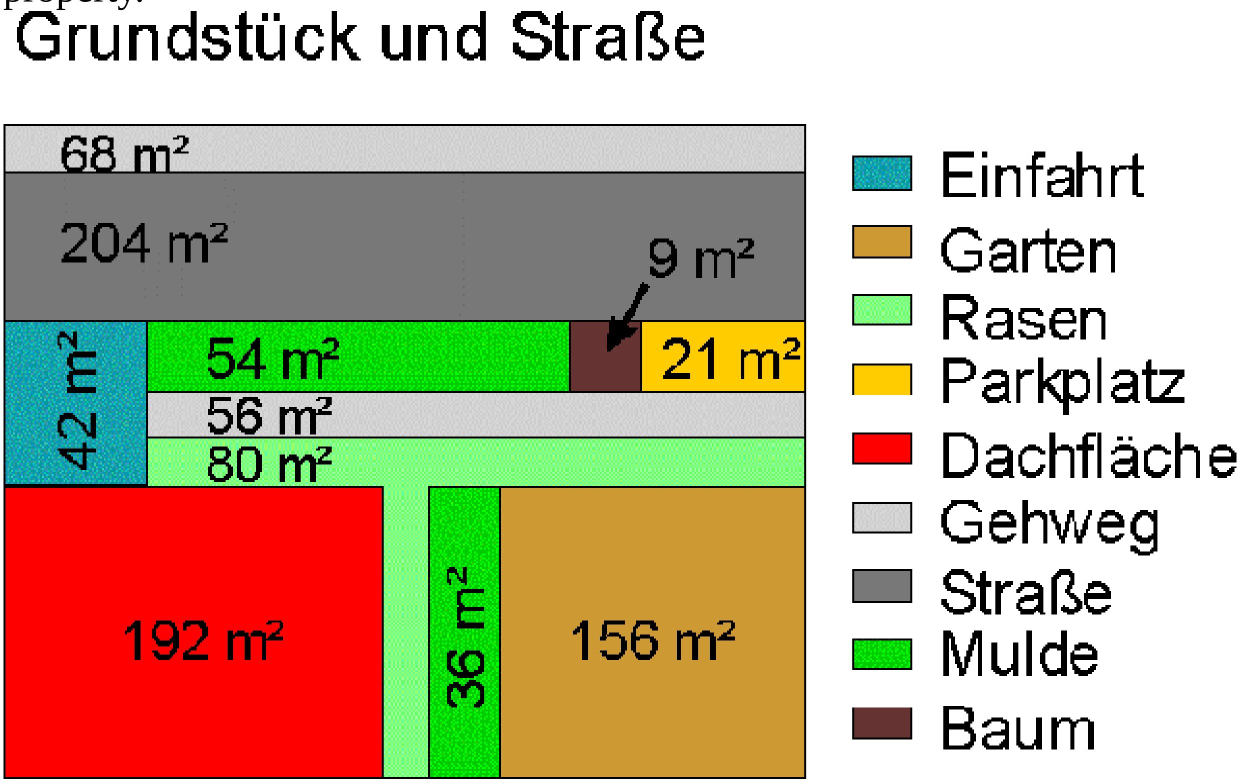


Here we're dealing with a piece of land with a house and a section of roadway. The project is small on purpose so that it is clearly arranged and understood. Of course, you can certainly work on much larger projects.

2.2 Demonstration of a Sample Project

Diagram of the Surface

The drainage for this example is divided into drainage for private and public property.



On the public property, we must take into account the roadway, pedestrian pavement (sidewalk), parking spaces for private cars and driveways to private property.

On the private property, we include roofed surfaces and unselaed surfaces in the runoff formation.

The graphic above shows a diagram of how each surface is set up. The area of each surface has already been determined.

2.3 Demonstration of a Sample Project

System Elements

To prepare the furfaces for input in STORM, it is advisable to become familiar with each of the system elements. These are:

- Rain gauges

- Evaporation

- Permeable runoff formation

- Impermeable runoff formation

- Surfaces

- Dry weather

- Catchments

- Green roofs

- Cisterns

- Surface infiltration

- Swales

- Trenches
- Swale-trench elements
- Innodrain(c)

- Connection pipes

- Stormwater retention tanks
- Retention tanks, online
- Retention tanks, bypass
- Throughflow tanks, online
- Throughflow tanks, bypass

- Stormwater overflows

- Retention drains

- Soil moisture elements

- Land uses

- Rivers and streams

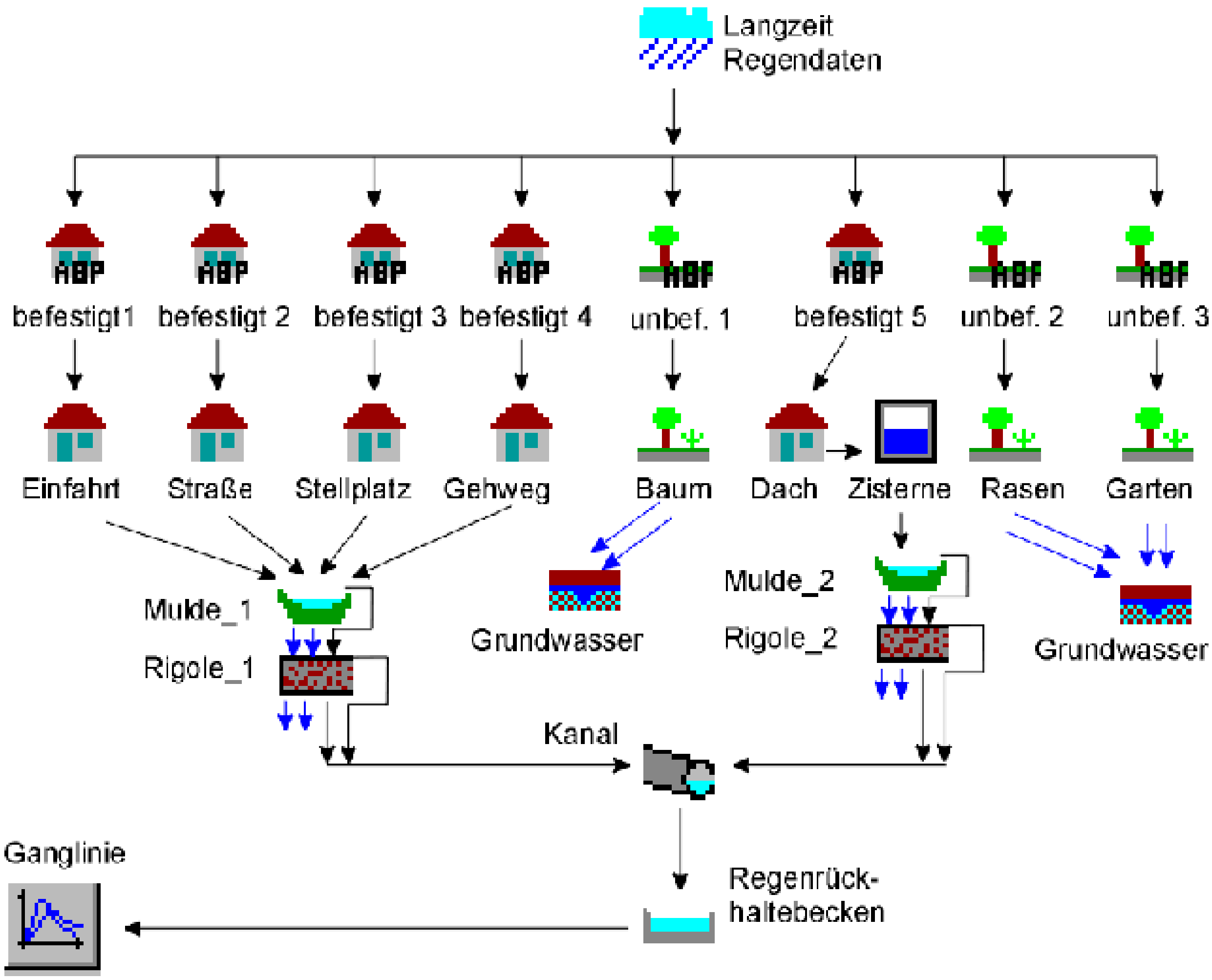
- Groundwater bodies

- Discharge hydrographs

- Wavefiles

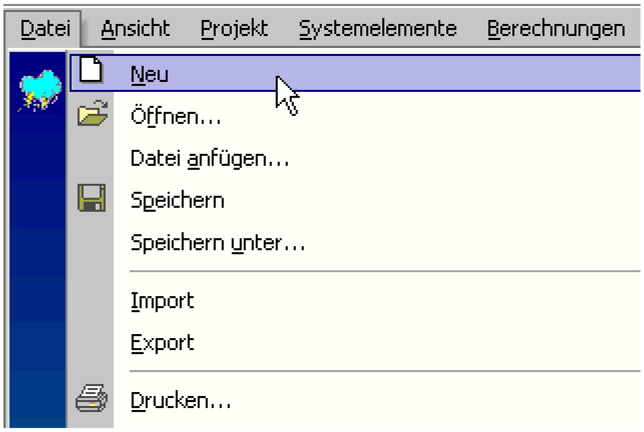
External inflows

The following graphic shows a structured diagram of our project for inputting in STORM.



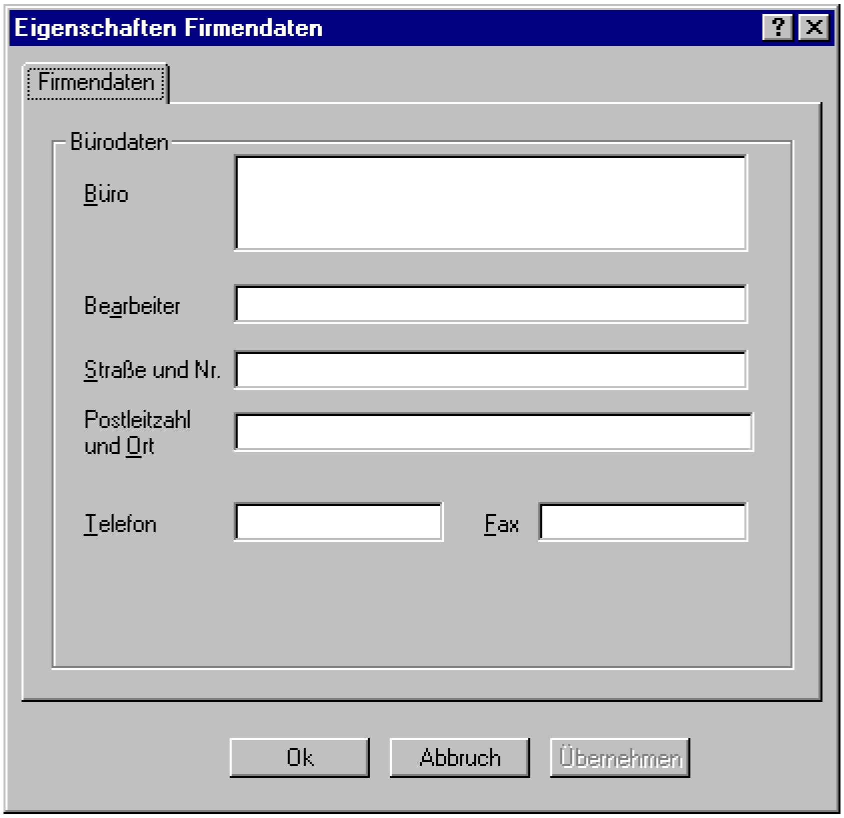
2.4 Entering a Sample Project

General Data Start a new project. Proceed as follows: In the File menu, click on "New".



Inputting General Data

In the structure tree, open the branch called "*General Info*" by clicking on the plus sign to the left of the branch and by double-clicking on *Company Data*. (see also Tree Structure View) Enter your company data.



Click on the *Apply* button (not the *Ok* button!). Your company data have been saved. The dialog window stays open.

Next, enter the data for the relevant project. For this you only need to click on "Project Data" in the element tree. The properties dialog updates itself automatically. You don't have to actually close the dialog and open a new one. This applies to all dialogs.

The abbreviations used in tables and dialogs are described in the *list of abbreviations*.

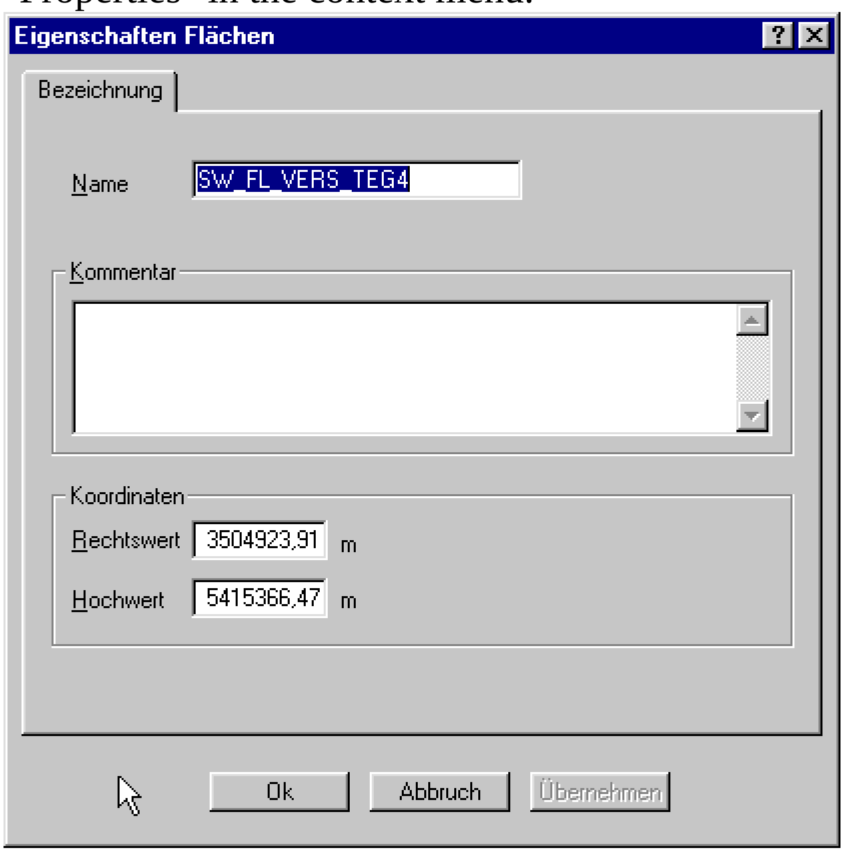
2.5 Inputting a Sample Project

Inputting Surface Data

Next, you input a sealed surface. This can be done three different ways: a) Click on this symbol

in the toolbar
b) Go to "New" in the System Elements menu and then choose the desired element.
c) Click on the subject heading "Surfaces" in the element tree with the right mouse button and then click on "Add new" in the context menu.

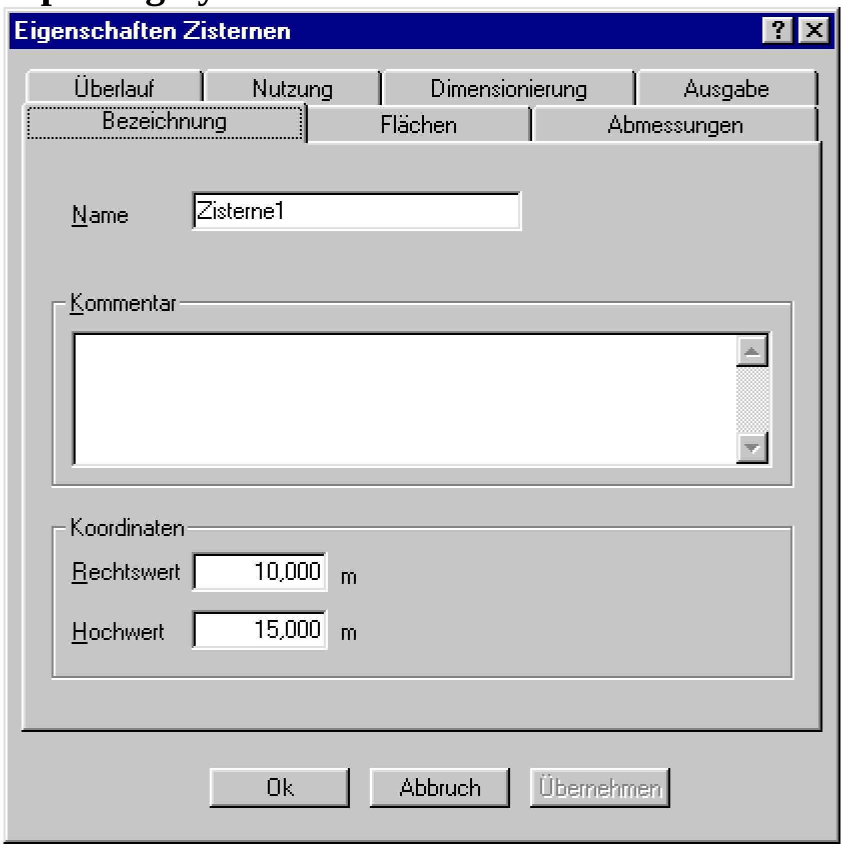
Open the properties dialog for the newly created surface. Even for this task there are three different possibilities.
a) Double-click on the surface element in the tree structure.
b) Go to "Properties" in the System Elements menu.
c) Click on the element with the right mouse button and then click on "Properties" in the context menu.



The properties dialog for the element appears and the "Designation" tab is active. Enter a name for the surface. This name must be individual, i.e. no other element, not even another kind, can have the same name.
Now switch to the "Surface" tab. Here, enter the size of the surface and the destination. If you've still not defined a destination, you must do this first.
In the "Runoff Formation Parameters" tab, you assign an appropriate pre-defined set of runoff formation parameters to the surface.
In the "Rain Gauge" tab, you indicate the rain gauge assigned to the surface.

2.6 Inputting a Sample System

Inputting System Element Data



Enter a new swale or another drainage element as demonstrated previously. Open the properties dialog. In the "Dimensions" tab, enter the swale's geometric data. If you need help with any of the input fields, press the F1 key or click on the button with the mouse pointer and the question mark in the toolbar or click on the small question mark in the upper right corner of the dialog window, and then click on the area you'd like information for.

Connecting the Surface to the Swale

Open the dialog for the surface element again and click on the "Surface" tab. In the "*Choose Destination*" section there is another tree structure shown. Open the "Swales" branch. The newly inputted swale should appear there. By clicking on this element, the swale is selected as the destination for the surface runoff. In the "Dest. Name" field, the name of the swale appears.

With this described process you can now enter more elements and link them. It is important to make sure the elements are connected correctly. You can check this by clicking on a main subject heading in the tree structure (such as drainage elements). You'll then see the table of drainage elements and their drainage destinations shown.

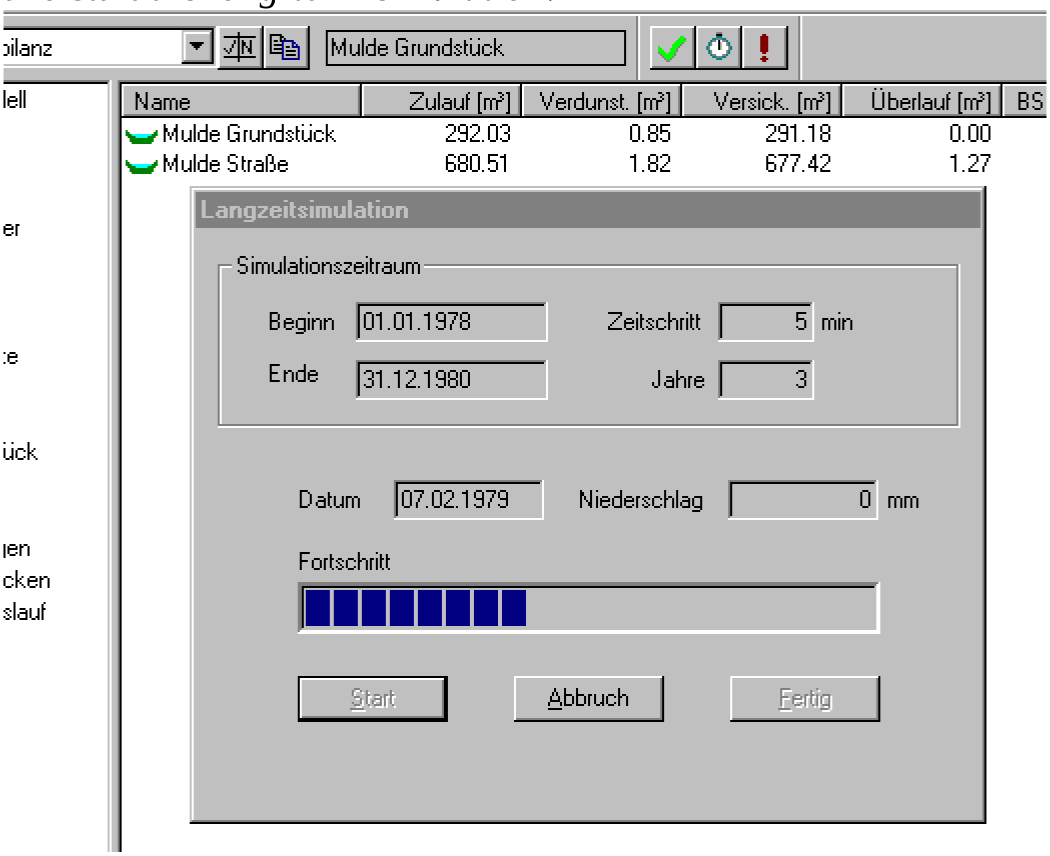
The last element in the flowchain must be an element from the natural water cycle that represents the outlet for the system.

The abbreviations used in the tables and dialogs are described in the *list of abbreviations*.

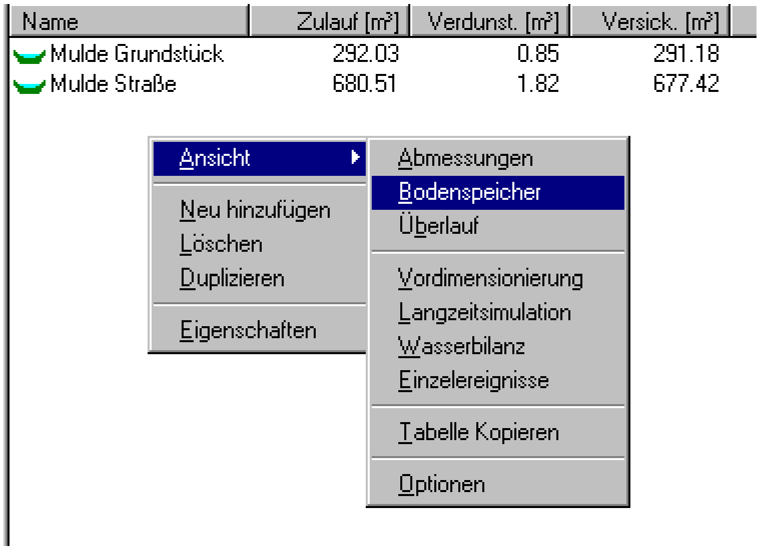
2.7 Demonstration of a Sample Project

Course of Calculation After you'ved finished entering all inputs, you can start the *calculation process* by first running a *data check* in the "Computation" menu. You can then carry out *pre-dimensioning* for your entire system.

Once you've applied the pre-dimensioned values and corrected the entries, you can open the *Long-term simulation* dialog window in the same menu and start the *long-term simulation*.



You can view the results in each of the elements' tables. With the context menu you can select which tables you want to view.



Under the results you'll find the total water balance for all elements.

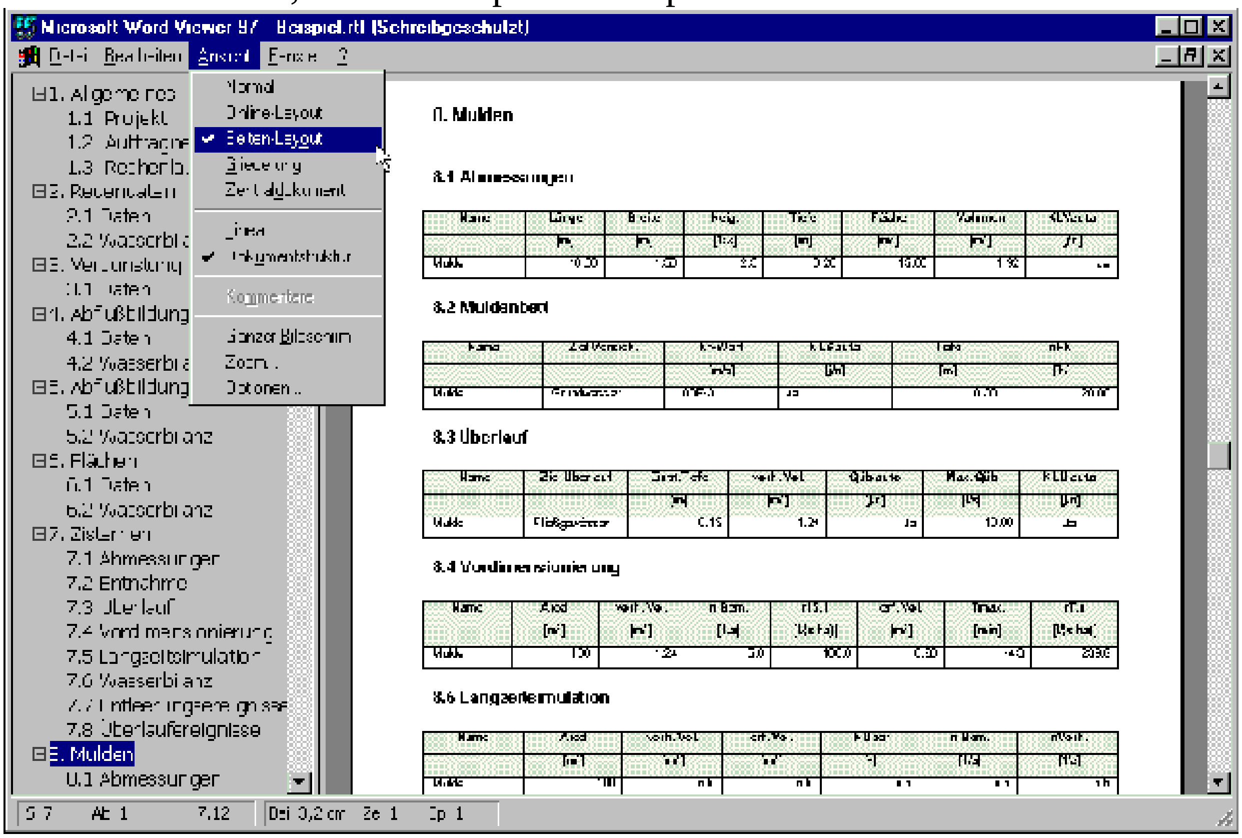
2.8 Demonstration of a Sample Project

Results Report

The input data and results of the computation are output for the report in a .rtf file that you can view and print with the included version of *Microsoft WordViewer97*. This is well suited for submitting to clients or authorising agencies.

A good overview of the results is assured by its.

You can also view, format and print the report with a word.



The abbreviations used in the results report are described in the *list of abbreviations*.

We hope to have given you a quick overview of the functionality of the programme with this short introduction. If you have additional questions about using the programme, use the index and help search functions or the user handbook.

3.1 Hydrologische Systemelemente

Im Modell STORM© werden verschiedene Systemelemente unterschieden:

- Regendaten,
- Verdunstung,
- Abflussbildungsparameter,
- Flächen,
- Speicherelemente und
- Verbindungsleitungen
- Elemente zur Bilanzierung der Zuflüsse zum Grundwasser, zu Fließgewässern und zum Systemauslass
- Abflussganglinienobjekte

Folgende Speicherelemente sind implementiert:

- Zisternen
- Mulden[1]
- Muldenbett (Bodenspeicher),
- Rigolen und
- Regenrückhaltebecken

Weitere Elementtypen (z.B. Teiche oder Mischwasserbauwerke) sind in Vorbereitung. Bedingt durch die objektorientierte Struktur des Programms sind neue Elemente relativ einfach zu realisieren.
Mit Ausnahme des Typs *„Regenschreiber“* können von jedem Typ beliebig viele Elemente erzeugt werden. Die einzelnen Systemelemente werden miteinander verknüpft.

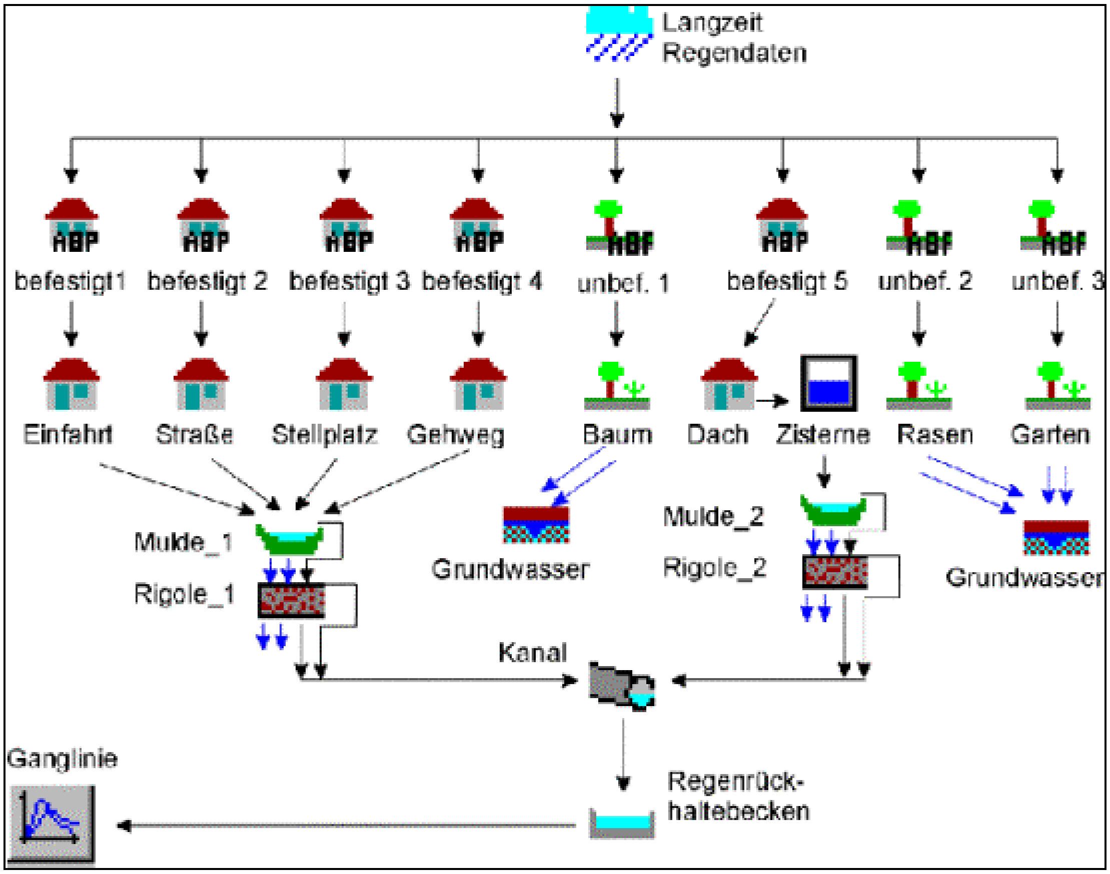


Abbildung 4-1: Systemelemente in STORM©, dargestellt anhand eines Beispiels

3.1.1 Rain Data

The hydrological system is tested by presenting it with rain data. Precipitation data must be present as equidistant precipitation depths in digitized mass data format (MD - format), which is used for the programs HYSTEM/EXTRAN (a German sewage channel hydraulics model) and KOSIM (a German solute loading model for urban areas). Thus, any precipitation specificationscan be considered (block -, model -, natural rains). For the continuum simulation, the precipitation recordings must be in digitized form and must be from at least one rain gage station, which is representative of the area of application. Past experience shows that the continuous recorded rain data must encompass a time frame of at least 10 years.

In order to be able to take the effects of strongly varying periods of precipitation, the interval for the precipitation data should not be too large. In STORMę, 5-minute values are used by default.

3.1.2 Evaporation

Evaporation processes should be taken into account in various components of a precipitation-runoff model. During the process of the runoff formation on impermeable or permeable surfaces, evaporation causes the drainage of water retained on surfaces that neither infiltrates or runs off. With storage elements with an open water surface, e.g. with an impounded infiltration swale, evaporation is a process that contributes to emptying the storage. Likewise, water is removed from soil storages through evaporation processes.
The potential (energy-able) evaporation hv can vary greatly depending on time and place and is difficult to access for an exact calculation. To make it easier, an average year hydrograph of the daily evaporation rate is used:

$$\Delta h_v\ (i) = \frac{7}{9} \bullet \sin\left[2\pi/365 \bullet (i - 91) + 1\right] \bullet \frac{h_v}{365} \quad [\mathrm{mm/d}] \qquad (4.1)$$

where i = numbered day of the runoff year (January 1: i = 1)
hv = average yearly potential evaporation [mm/a]
Dhv(i) = current hight of evaporation in mm.
This hydrograph is shown graphically in Figure 4-2. The yearly potential total hight of evaporation for this hydrograph is 657 mm.

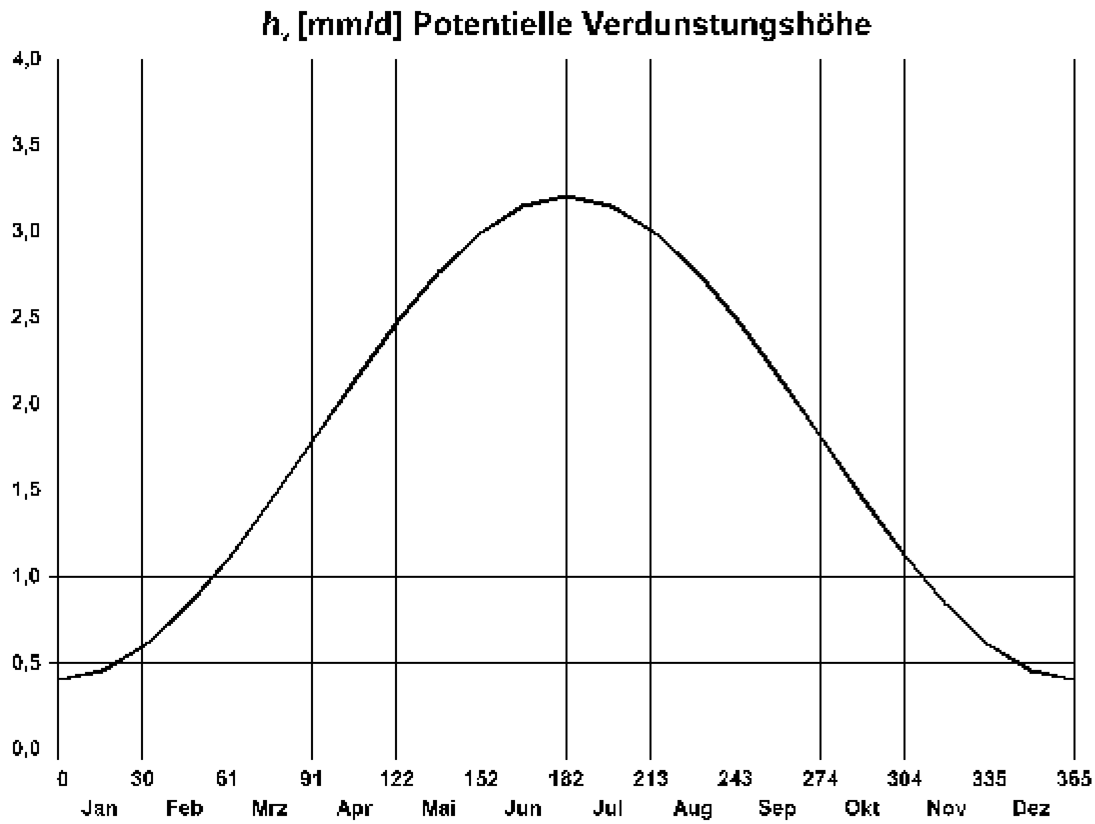


Figure 4-2: yearly hydrograph for potential evaporation

An average day hydrograph forms the basis for calculating the evaporation for each time interval as well. The implemented standard values for this day hydrograph were developed by the Institute for Hydraulic Engineering, TH Darmstadt, Department of Hydrology Engineering and Hydraulics (EULER, 1989) for implementation in the model SMUSI, and are shown in Figure 4-3.

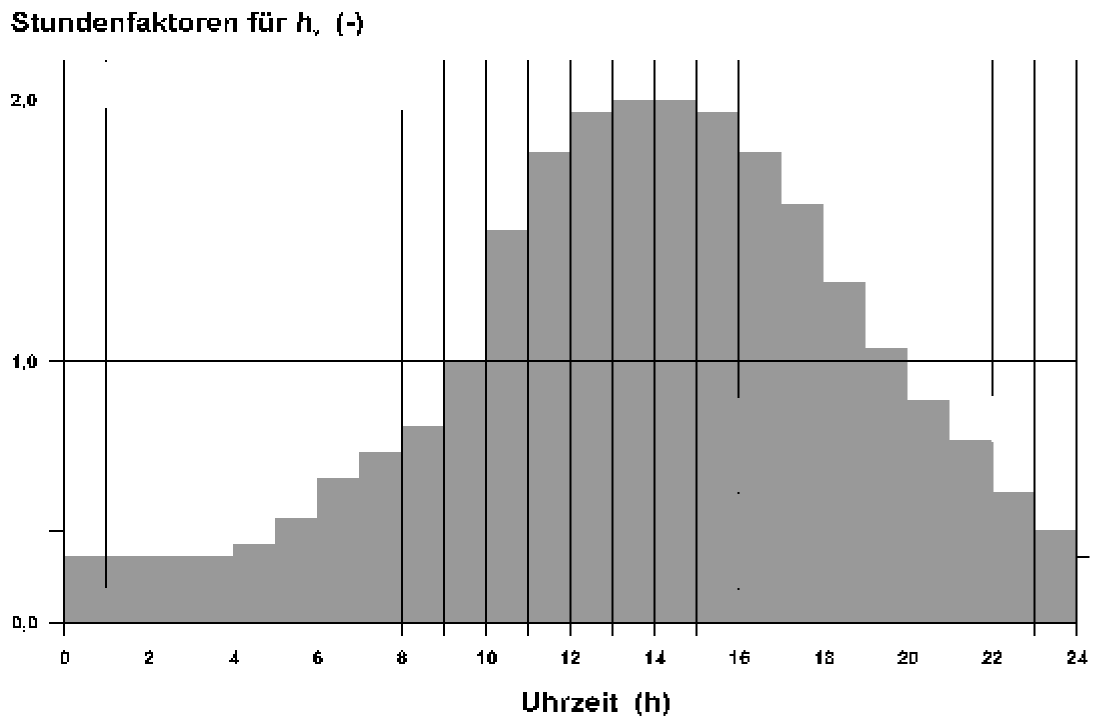


Figure 4-3: average day hydrograph for the daily evaporation rate

3.1.3 Runoff Formation Parameters

With long-term simulation, the method to the runoff formation for a model carries particular weight. The correct calculation of runoff-effective portions from small as well as large precipitation events is of importance for the calculation of the runoff continuum, since not only the total runoff of single events, but also initial conditions for subsequent precipitation-runoff events must be determined.

Essentially, different approaches to the runoff formation for

- impermeable surfaces and for
- permeable surfaces

are practical and useful.

3.1.3.1 Runoff Formation Parameters for Impermeable Surfaces

The continuous simulation of runoff formation processes on impermeable surfaces requires differentiation between

- rainy phases and
- dry phases.

STORM© contains a method for runoff formation according to the limit value method. A special case of this method was developed by Paulsen (1987), which was improved by Verworn and Kenter (1993). The following parameters are considered:

hb of wetting losses (in mm) are treated as threshold values and subtracted from the precipitation data at the beginning of a rain. Depending upon the intensity of the rain the subtraction occurs only within the calculation interval and extends over several intervals.

hm once the wetting losses are accounted for and the rainfall continues, the trough begins to fill with water, which is designated as the trough storage loss.

yo The limit value method assumes that at the beginning of the trough filling phase, a certain surface fraction, called the initial runoff coefficient, is already effective for discharge.

ye during the trough filling phase, the discharge-effective surface fraction increases from yo until all trough storage losses have been accounted for (h_m) and the final runoff coefficient ye is achieved. In particular the final discharge factor represents the ratio of discharge-effective surface to permeable surface area. The difference 1 - ye represents the continuous losses.

Derivation of Runoff Formation

Balancing the wetting storage occurs as follows:

Contents of the wetting storage VB_i (at time i) N_i is determined from the total available of the previous wetting storage volume VB_{i-1} and the precipitation depth $h_{N},_{i}$. In the precipitation phase the wetting storage is filled to a maximum value h_b. This maximum is an input parameter whose value depends upon the drainage surface type.

$VB_i = VB_{i-1} + h_{N,i}$ mit $VB_i \le h_b$ (4.2)

$h_N = h_{N,i} - (VB_i - VB_{i-1})$ (4.3)

The remaining precipitation h_N, which is the difference between the available precipitation $h_{N,i}$ fallen in the time interval *i* and the replenishment of the wetting storage, enters the subsequent calculation of the effective precipitation, taking trough storage losses and initial and final runoff coefficients into consideration.

For the further derivation the wetting need not to be considered. Assuming that the regarded catchment area surface contributes the total discharge amount, the discharge-effective precipitation proportion of $h_{Ne,i}$ at time *i* of a rainfall event is found from:

$h_{Ne,i} = h_N - h_{m,i}$ (4.4)

The height of precipitation h_N is reduced by a proportion $h_{m,i}$ (losses by trough retention). An exponential function is used for the trough storage losses $h_{m,i}$:

$h_{m,i} = h_m \bullet (1 - e^{-\alpha \cdot h_N})$ (4.5)

$h_{m,i}$ can have a maximum of h_m which is defined by the user according to the type of available discharge-effective surface.

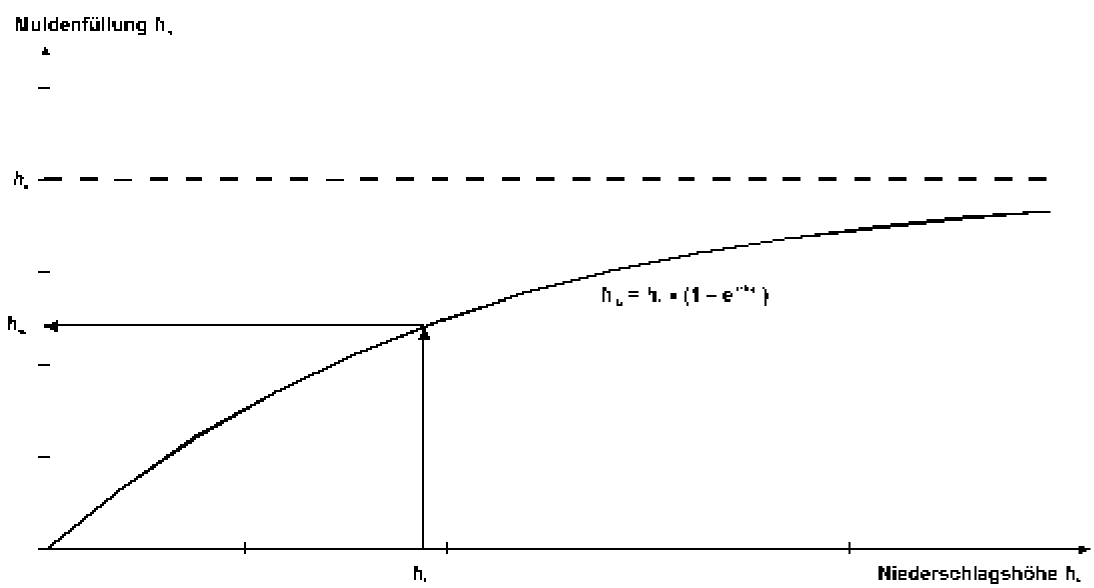


Figure 4-4: Trough filling as a function of precipitation depth

Placing Equation 4.5 into 4.4 brings about the following:

$h_{Ne,i} = h_N - h_m \bullet \left(1 - e^{-c \bullet h_N}\right)$ (4.6)

The coefficient *c* is a measure for the development of the trough loss process.

It is the nature of the limit value method, that the runoff coefficient y changes after each interval and can be derived by the differential quotient of discharge and precipitation.

$\psi = \frac{\mathrm{d}\, h_{Ne}}{\mathrm{d}\, h_N}$ (4.7)

Replacing h_N with Equation 4.6 gives:

$\psi = 1 - h_m \bullet c \bullet e^{-c \bullet h_N}$ (4.8)

c can now be determined, if it is assumed that the initial runoff coefficient takes effect as soon as the trough begins to fill up with water i.e.:

$\psi = \psi_0$ für $h_N = 0$ liefert :

$\psi_0 = 1 - h_m \bullet c$ (4.9)

From this follows:

$c = \frac{1 - \psi_0}{h_m}$ (4.10)

and by placing into Equation 4.8 and re-arranging, one receives a function for the runoff coefficient:

$\psi = 1 - \left(1 - \psi_0\right) \bullet e^{-c \bullet h_N}$ (4.11)

All these equations are applicable using the precipitation depths from the beginning of an event. For a continuous simulation, however, a stepwise, recursive calculation is better suited. This requires the degree of trough filling $e_{m,i}$, which from Equation 4.5 becomes:

$\varepsilon_{m,i} = \frac{h_{m,i}}{h_m} = 1 - e^{-c \bullet h_N}$ (4.12)

The degree of trough filling is in the range between 0 and 1 and changes according to the modification of the precipitation depths from one interval to the next. Using the exponent function rule:

$e^{-c \bullet (h_N + \Delta h_N)} = e^{-c \bullet h_N} \bullet e^{-c \bullet \Delta h_N}$ (4.13)

Thus, the degree of trough filling can now be determined for the next time step *i* + 1:

$$\varepsilon_{m,i+1} = 1 - \left(e^{-c \cdot h_N} \bullet e^{-c \cdot \Delta h_N}\right) \quad (4.14)$$

From Equation 4.12:

$$e^{-c \cdot h_N} = 1 - \varepsilon_{m,i} \quad (4.15)$$

and Equation 5.12 can be written in such a way that the degree of trough filling can be calculated recursively from the current precipitation depth D*h* $_N$.

$$\varepsilon_{m,i+1} = 1 - \left(1 - \varepsilon_{m,i}\right) \bullet e^{-c \cdot \Delta h_N} \quad (4.16)$$

Likewise, the work equation for the discharge-effective precipitation can also be calculated in a stepwise fashion according to Equation 4.6, whereby the size of the time step should be arbitrary. This can be achieved, if one integrates the runoff coefficient (Equation 4.11) over the time step:

$$\Delta h_{Ne,i} = \int_{N=h_{N,i-1}}^{N=h_{N,i}} \psi(h_N) \; dN \quad (4.17)$$

Replacing y(h_N) with Equation 4.11, the resulting integration yields:

$$\Delta h_{Ne,i} = \Delta N_i - h_m \bullet \left(e^{-c \cdot h_{N,i-1}} - e^{-c \cdot h_{N,i}}\right) \quad (4.18)$$

The bracketed term can be replaced by the appropriate degree of trough filling to obtain a recursive work equation:

$$\Delta h_{Ne,i} = \Delta h_{N,i} - h_m \bullet \left(\varepsilon_{m,i} - \varepsilon_{m,i-1}\right) \quad (4.19)$$

For the derivation of Equation 5.18 it is assumed that only wetting losses and trough storage losses occur for the discharge surface. In particular, no continuous losses are considered. Continuous losses are described more meaningfully by the final runoff coefficient y$_e$, which, again, can be interpreted as the ratio of the discharge-effective surface A_{red} to the total area *A*:

$$\psi_e = \frac{A_{red}}{A} \quad (4.20)$$

When considering the continuous losses, Equation 4.19 must read as follows:

$$\Delta h_{Ne,i} = \psi_e \bullet \left[\Delta h_{N,i} - h_m \bullet \left(\varepsilon_{m,i} - \varepsilon_{m,i-1}\right)\right] \quad (4.21)$$

Fig. 4.5 shows the typical plot of the runoff coefficient for a constant precipitation.

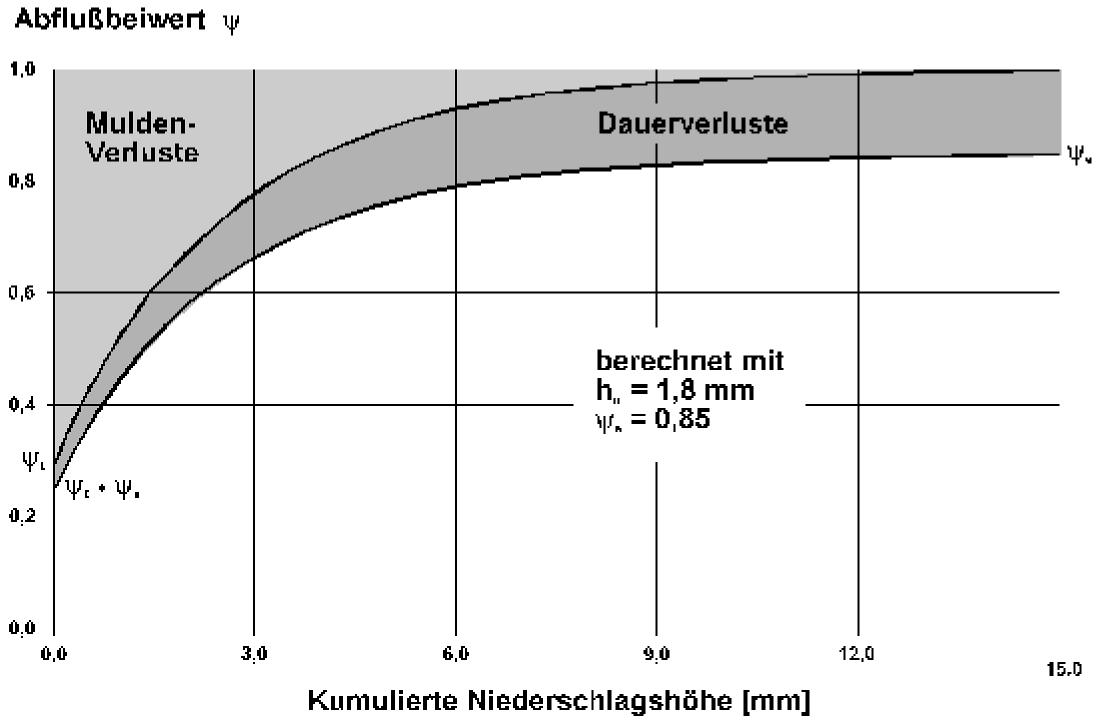


Figure 4-5: Plot of the runoff coefficient y with and without continuous losses (Verworn and Kenter 1993)

Processes in the drying phase

The decrease of the surface moisture, as well as, the draining of the troughs on the discharge-effective surfaces are treated as a storage problem. In the precipitation phase storage is filled by wetting and trough replenishment and emptying takes place by evaporation.

The processes of regional dryingare extraordinarily complex. Model equations were developed by Paulsen (1987) taking into consideration the decrease of the evaporation-effective trough surface and the losses due to splash-water. Correct handling of its algorithms, however, requires substantial numerical expenditure within the model. If a trough is still partly filled and precipitation occurs which does not lead to overflowing of the trough, averaging and correcting is necessary for the computation. Since this expenditure does not increase accuracy, a strongly simplified formulation is implemented STORM©:

$$\varepsilon_{m,i} = \varepsilon_{m,i-1} \bullet e^{-c \bullet \Delta h_{v,i}} \quad (4.22)$$

where D$h_{v,i}$ = actual evaporation depth [mm]

This decrease in the degree of trough filling through evaporation only takes place during the drying phases. Also, the reduction of the wetted storage volume takes place via evaporation:

$$VB_i = VB_{i-1} - \Delta h_{v,i} \quad (4.23)$$

where VBi = wetted storage volume at time *i*

Dhv,i = evaporation losses *i*

In general, it is also important to consider the evaporation during the precipitation phase, as is the standard case for the models SMUSI and LWAFLUT. Therefore, evaporation during precipitation events may also be considered when using TRINTSIM (the default case).

In the case that evaporation is to be computed during precipitation events, the previous equation is applied to each calculation time step. Essentially, the wetting storage volume is reduced by an amount corresponding to the potential evaporation depth. In summary, for each time step the above equations result in the reduction of the gross precipitation by at least the potential evaporation depth and at most by the maximum wetting losses h_b.

Compilation of the Computational Equations

For the simulation of the runoff formation on impermeable surfaces, the following computational equations are necessary:

$$\Delta h_{Ne,i} = \psi_e \bullet \left[\Delta h_{N,i} - h_m \bullet \left(\varepsilon_{m,i} - \varepsilon_{m,i-1}\right)\right] \quad (4.24)$$

trough filling during the precipitation phase:

$$\varepsilon_{m,i+1} = 1 - \left(1 - \varepsilon_{m,i}\right) \bullet e^{-c \bullet \Delta h_N} \quad (4.25)$$

Emptying of the trough during the drying phase:

$$\varepsilon_{m,i} = \varepsilon_{m,i-1} \bullet e^{-c \bullet \Delta h_{v,i}} \quad (4.26)$$

Before application of the algorithms the wetting losses h_b are first calculated. The auxiliary variable *c* becomes:

$$c = \frac{1 - \psi_0}{h_m} \quad (4.27)$$

Default Values for the Runoff Formation Parameters

For TRINTSIM, standard parameters of the runoff formation for each loss type are suggested (see Table 4.1), which can be changed by the user (in tagged sheet “Runoff formation“ in the dialog window “Properties Runoff formation parameters“). The chosen parameters affect the entire system; deviations in the loss amounts for individual subsections cannot be defined.

Surface Type	Wetting losses *hb* (mm)	Trough losses *hm* (mm)	Initial discharge coefficient y*0* (1)	Final discharge coefficient y*e* (1)

Sloped roof	**0,3**	**0**	**1,0**	**1,0**

Flat roof

2,0	**0**	**1,0**	**1,0**

Walkways	**0,7**	**1,8**	**0**	**0,75**

Streets	**0,5**	**1,8**	**0**	**0,95**

Table 4.1: Default values in STORM© for Runoff Formation Parameters

For further reading of the runoff formation parameters the reader is referred to Verworn and Kenter (1993).

3.1.3.2 Runoff Formation Parameters for Permeable Surfaces

The runoff from permeable surfaces can have a significant impact on the runoff behaviour for a catchment. Compared to the computation of the runoff formation on impermeable surfaces, the simulation for permeable surfaces is more complicated and infiltration must be taken into account. In addition, permeable surfaces are less homogenous and vary much more greatly locally in plant cover and type of surrounding soil. Furthermore, with permeable surfaces, it is often difficult to judge whether the runoff eventually makes it into the drainage facilities or not.

For the modelling, the basic principles surrounding impermeable surfaces in terms of evaporation for rainy and dry periods apply as well. Likewise, the methods for the runoff formation can be applied as well, but they must be extended to the "Infiltration" components.

The calculation of the runoff formation for permeable surfaces thus consists of three components:

- Wetting and interception losses
- Infiltration
- Swale losses and chronological progression of the runoff coefficient

Wetting and Interception Losses

Just like with wetting losses for impermeable surfaces, initial losses occur with permeable surfaces. Along with the actual wetting losses on the surface, plants catch a portion of the precipitation so that it never makes it to the soil. This loss is called interception loss. Interception losts are, however, in contrast to the wetting losses on impermeable surfaces, not constant, but rather chonologically variable, since they are determined from the current vegetation.

In the STORM© model, a basis is formed for a seasonal change of interception losses. For this, the maximum interception losses that occur during the Summer are reduced during the other seasons.

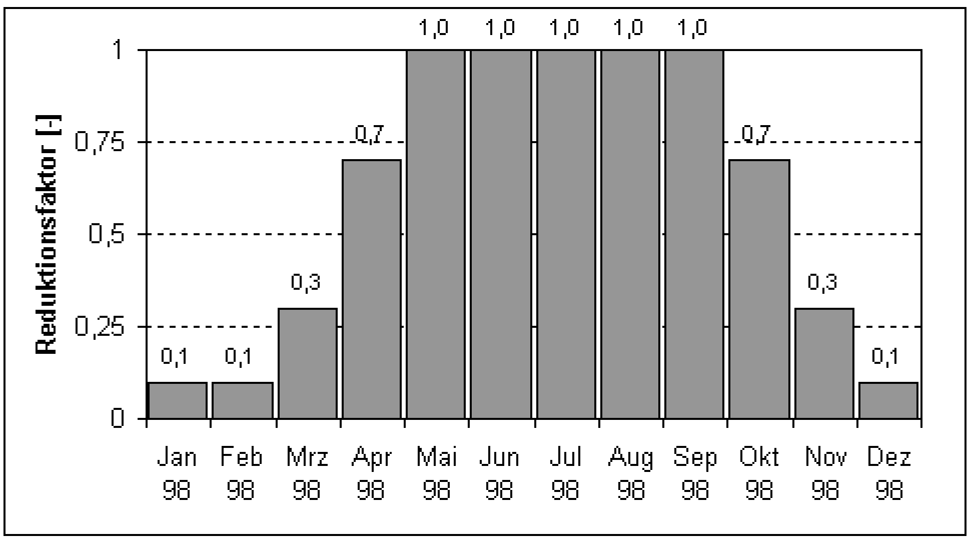


Figure 4-6 Reduction of the wetting and interception losses as a function of the seasonal vegetation

The calculation of the regeneration of the wetting and interception losses occurs by considering the potential evaporation.

Infiltration

The following described approach to infiltration describes the infiltration of precipitation on permeable surfaces. This approach is based on the HORTON method and was further developed by PAULSEN (1986).
The HORTON method (equation 4.2) describes the changing infiltration capacity, assuming that from the initial infiltration rate until the final infiltration rate is only a function of time. It is also assumed that during this time, the rain intensity is constantly the same or larger than the current infiltration capacity. This is, however, not necessarily the case during any old rain event. Furthermore, for a time-step simulation, even the reverse change, namely back to the initital infiltration rate, occuring in rain-free or drier periods should be taken into account.

HORTON Method:

$f(t) = f_e + (f_0 - f_e) \bullet e^{-k \bullet t}$ (4.28) where f(t): Infiltration rate at time t [mm/min]

f0: Initial infiltration rate at time t=0

fe: Final infiltration rate at time t=¥

k: Regression constant (1/min)

or, in the recursive form:

$f_i = f_e + (f_{i-1} - f_e) \bullet e^{-k \bullet \Delta t}$ (4.29) where fi: Infiltration rate for the (i)th time interval

fi-1: Infiltration rate for the last time interval fe: Final infiltration rate at time t=¥

k: Regression constant (1/min)

This method, valid only for the case when precipitation intensity > infiltrations rate, was extended by PAULSEN (1987) for cases when precipitation intensity < infiltration intensity and precipitation intensity = 0 by using the HORTON equation reciprocally as a function to describe the reboost in the potential infiltration intensity. The regression constant "k" is replaced by the increase constant kD.

$f_i = f_0 - (f_0 - f_{i-1}) \bullet e^{-k_D \bullet c_{hv} \bullet \Delta t}$ (4.30) where f0: Infiltration rate at time t=0

kD: Regeneration constant

chv: Ratio of current/average hight of evaporation

If the impact is less than the potential infiltration intensity, the precipitation interval t is segmented into two parts. In the first part, a time span corresponding to the precipitation is set with the exact impact that corresponds to the potential infiltration, which has, as a consequence, a regression of the infiltration capacity. In the second part, the impact is set to zero; the infiltration capacity rises again accordingly. To explain the different phases, the PAULSEN approach is shown in Figure 4-7.

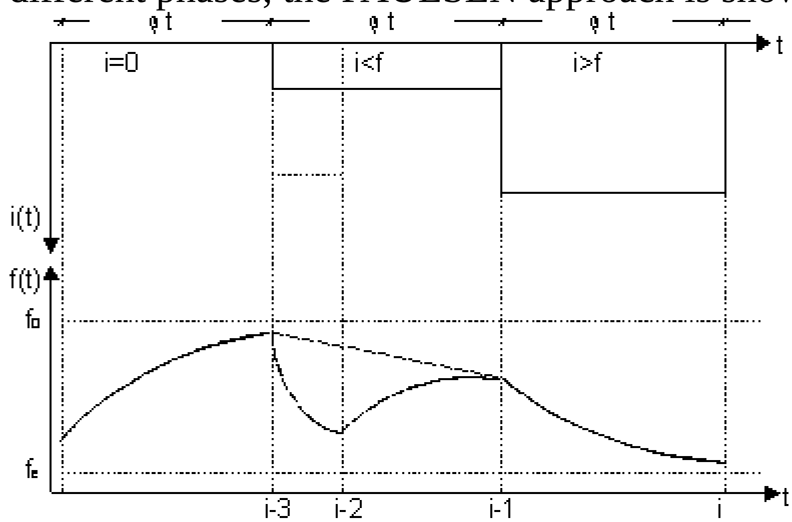


Figure 4-7 Regeneration and Exhaustion of Infiltration Capacity

Swale Losses and Chronological Progression of the Runoff Coefficient

After the wetting and interception losses have been taken up and a portion of the precipitation is infiltrated, the swales become filled. Due to the differences between each of the permeable surfaces within a (partial) catchment, the swale losses to be applied are also very different. Consequently, one part of the surface yields runoff sooner than another part so that an increase of the runoff effective permeable surfaces occurs.

This behaviour corresponds to that of impermeable surfaces and can be described in an appropriate way with the limit value method. However, the parameters should of course be selected differently and, in part, also interpreted differently. The swale losses here additionally describe th various losses on permeable surfaces. Principally, the equations for the limit value method also apply as with impermeable surfaces.

3.1.4 Discharge Concentration

The discharge concentration determines the occurrence of the temporal distribution of discharge at a certain location (e.g. in the inlet of a trough), i.e. the shape of the discharge wave. STORMİ makes it possible to regard the runoff concentration as of the available version 4.0.

In order to calculate meaningful discharge concentrations which incorporate the runoff formation of all the short flow paths (e.g. small roofs and yard surfaces), the precipitation data would need to have a time resolution of at least one minute. Furthermore, the shape of the discharge wave when dimensioning storage components like swales, trenches or cisterns is of lesser importance. Therefore, the discharge concentrations for this application are not necessary for the calculations and are also not taken into account when connecting a surface directly to the element.

When calculating the precipitation runoff processes in larger catchments, however, the process of the discharge concentration can no longer be neglected. Because of this, the "Catchment" element has been introduced in STORMİ. This element offers the possibility to take the discharge concentration into account for a number of surfaces that make up a larger catchment and from which a longer flowtime results.
For this, the mathematical model of the storage cascade is introduced. This is the further development of the linear single storage. The linear storage cascade consists of several single storages that are switched to an in-line cascade.

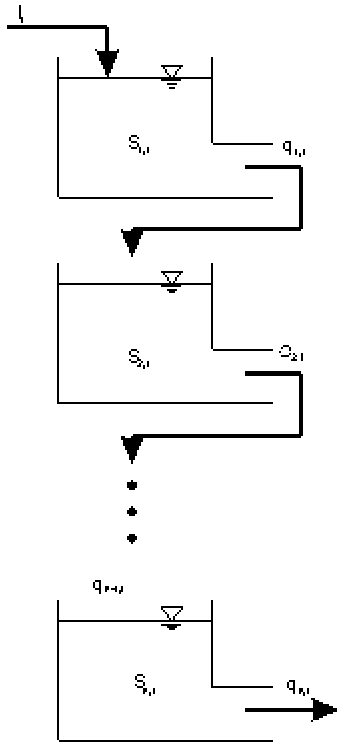


Figure 4-8 Linear storage cascade

The discharge from the upper storage is the inflow to the next storage. For each storage element, the differential equation of the linear single storage applies. Principally, various characteristics of the storage are conceivable; generally, however, the same storage constant k is used for all storages.

$$q_{1,t} + K \bullet \frac{dq_{1,t}}{dt} = I_t$$

$$q_{2,t} + K \bullet \frac{dq_{2,t}}{dt} = q_{1,t}$$

.

.

.

$$q_{n,t} + K \bullet \frac{dq_{n,t}}{dt} = q_{n-1,t} \qquad (4.31)$$

PAULSEN [1987] gives this equation as a solution for the differential equation system for dt <= K:

$$q_t = \frac{I_t}{K \bullet (n-1)!} \bullet \left(\frac{t}{K}\right)^{(n-1)} \bullet e^{-\left(\frac{t}{K}\right)} \qquad (4.32)$$

The effect of the model parameters n and K is similar. A large value for the storage constant K enlarges the retention period and curbs the runoff hydrograph. A large number of storages n likewise has a dampening effect.

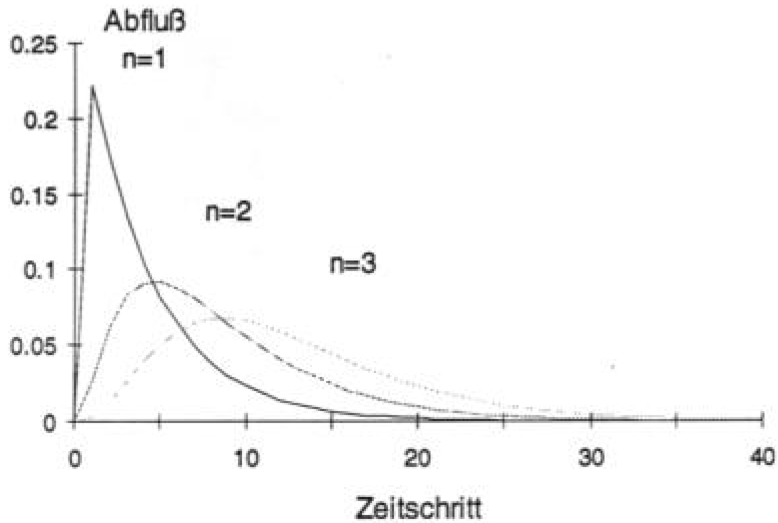


Figure 4-9 Variation of the number of storages

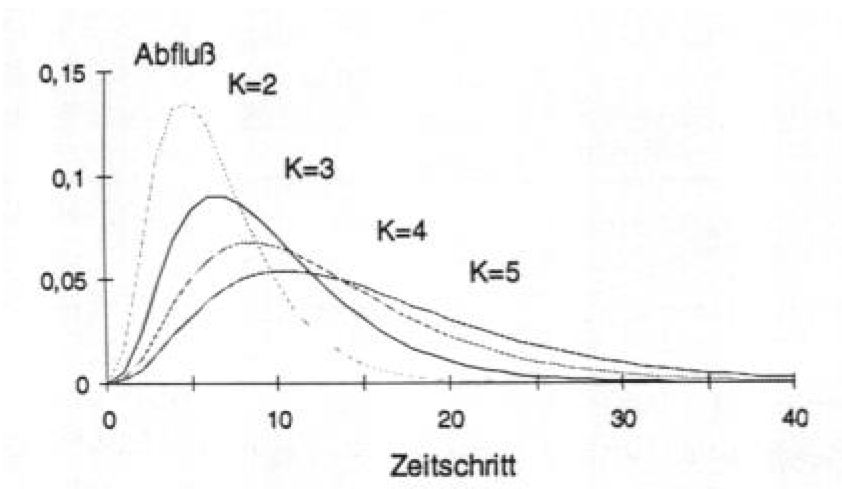


Figure 4-10 Variation of the storage constants when n=3

Calculating storage cascades does not occur in STORMİ according to the superposition principle, but rather recursively. This way the calculation time is considerably reduced.

A detailed explanation of the principle of the storage cascade and a derivation of the recursive calculation methods is contained in SCHOLZ [1995].

3.1.5 Storage Elements

Calculating storage elements in STORMİ occurs with the aid of characteristic curves. These curves describe the storage geometry and the elements' discharge components. The modelling approaches for cisterns, swales, swalebeds (soil storages), troughs and stormwater retention tanks are described as follows.
The curves mentioned have default values in the input masks that are calculated according to the following approaches. The user has the ability to input his own curves and to forgo the defaults given in STORMİ.

3.1.5.1 Cisterns

A cistern can be installed up- or downstream from a swale or another system element. Cisterns store rainwater with the intention that the stormwater can be utilised, e.g. for watering gardens or flushing toilets. Cisterns are generally used with roof surfaces.
This cistern storage is an element modeled with a constant discharge (withdrawal rate in l/d) and an overflow (see Figure 4-11). To calculate the degree of coverage, drinking water usage is also taken into account.

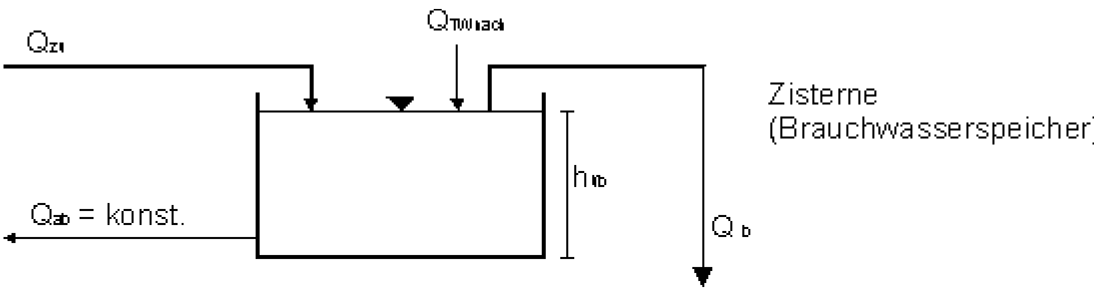


Figure 4-11 Flow scheme for a cistern

Geometry

By default, the cistern has the geometric shape of cube. The storage volume of the cistern is calculated as follows:

$V_Z(h) = l_Z \bullet b_Z \bullet h_{ü\partial}$ (4.33)

where Vz (h) = Storage volume for the cistern (m³)

lz = length of the cistern (m)

wz = width of the cistern (m)

hov = overflow hight or max. water level in the cistern (m)

When inputting data, the overlflow hight hov in the cistern is distinguished from the depth d of the cistern. The overflow hight is the value at which the overflow switches on. The depth is used in the calculation. The characteristic curve (see Figure 4-12) is created in STORM© automatically with 3 pairs of values.

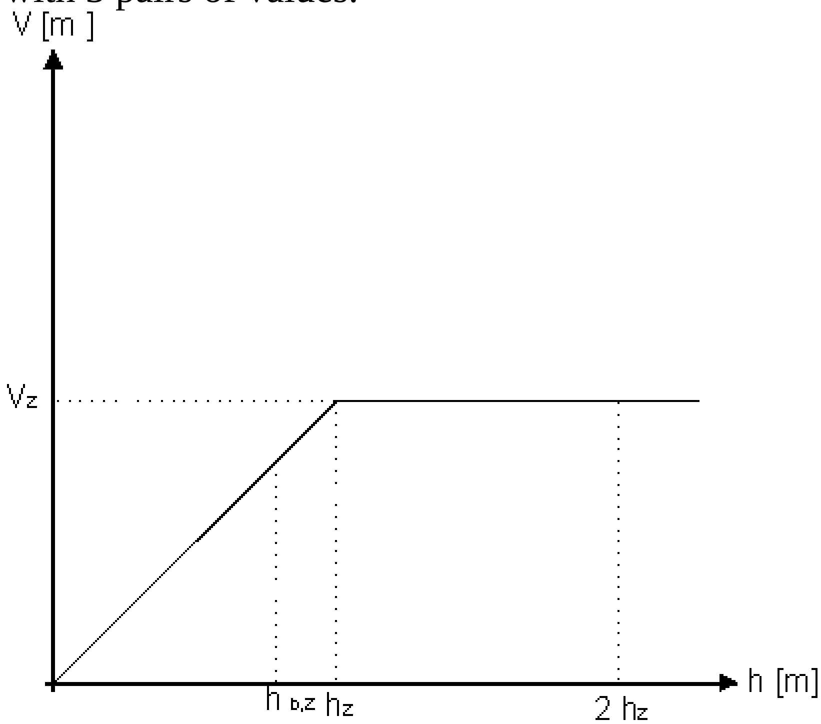


Figure 4-12 Characteristic curve for cisterns

Inflow

The inflow to the cistern is determined from the runoff formation calculation for assigned surfaces, (see Figure 4-11, QZU). If the cistern's volume is used up, the inflow becomes overflow into the downstream drainage element, e.g. an infiltration swale. If the cistern is empty, the water used for purposes usually supplied by the cistern then becomes supplied by normal drinking water sources.

Discharge

Discharge from the cistern is calculated from the utilisation of stormwater or drinking water. In STORM©, various uses are pre-defined.

For personal uses, from toilet flushing to washing maschines, it is important to indicate how many people are living in the household. For watering gardens or lawns, the surface area (in m^2) to be watered should be indicated.

Standard values are:

- Toilet (standard) 14 m^3/(Pers. a)
- Toilet (economy, low flush) 8 m^3/(Pers. a)
- Washing machine 6 m^3/(Pers. a)
- Watering gardens/lawns 6 m^3/(100m^2 a)

The predefined values can be overwritten by giving a daily withdrawal rate (in l/d).

The overflow Qo,c for the cistern is described by a characteristic curve. The overflow switches on when the water passes the cistern's overflow hight (hov) and reaches its maximum Qo,c,max with the cistern depth hC . The maximum value of the overflow curved Qo,C,max must be given. The value should be chosen so that the overflow capacity QO,M is larger, in every case, than the inflow QCU,C to be expected during impoundage of the cistern. Thus, the overflow volume in connection with the overflow frequency is a dimensioning criterium for a cistern. There can not be any amount of water that impounds beyond that of the predefined cistern volume.

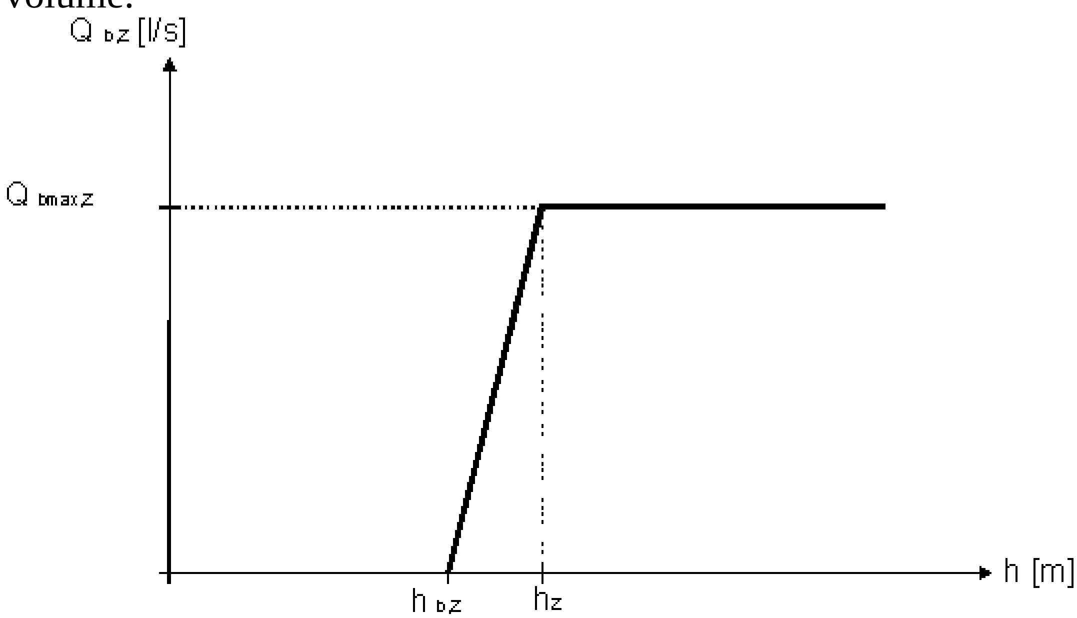


Figure 4-13 Overflow characteristic curve for cisterns

3.1.5.2 Swales

The precipitation runoff usually reaches the planted swale first in a swale-trench system. This trench represents a storage element whose discharge is led by infiltration via the swale bed to a trench. Even the "swale bed" element is a storage element and only effective with a swale. In the model, the swale bed is technically linked to the swale.
The swales all have an overflow. This leads the water flowing into the swale during swale impoundage directly into another system element such as a trench (without passing through the soil) or into another swale element.

Geometry

The geometry of the trough used in STORM© has the shape of an obelisk (see Figure 4-11).

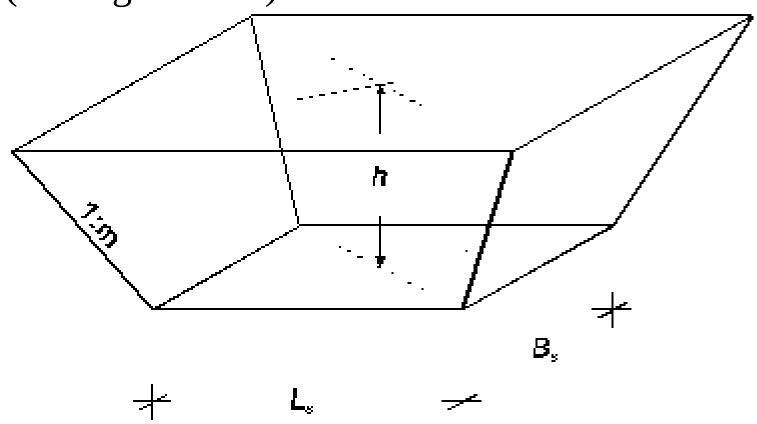


Figure 4-14: Swale geometetry, shown as an obelisk

the volume of the swale is determined with equation 4.34:

$$V_{Mulde} = \frac{1}{6} h \bullet [(2 \bullet L + L_S) \bullet B + (2 \bullet L_S + L) \bullet B_S] \quad (4.34)$$

where VMulde = storage volume in the swale (m³)

h = swale depth (m)

L = swale length (m)

B = swale breadth (m)

LS = swale bottom length (m) where $L_S = L - 2 \bullet h \bullet m$

BS = swale bottom breadth (m) where $B_S = B - 2 \bullet h \bullet m$

1:m = embankment slope (-)

The swale lenght L, swale breadth B, swale depth h and m for the slope are input values that are required to calculate the swale volume VMulde with equation 4.34.

When inputting data, overflow hight hü and depth h are differentiated, as with other storage elements. The overflow hight is the value at which the overflow switches on. The appropriate impound volume is determined likewise with equation 4.34, except that the swale depth h is replaced by the overflow hight hü.

The volume characteristic curve (see Figure 4-15) is created automatically in STORM© with 10 pairs of values. The additionally impounded water, is determined by extrapolating the volume in Figure 5.7 to twice the swale depth $h = 2 \bullet h_M$. The excess impounded water is to be understood as the water in addition to the available maximum storage volume of the swale which does not drain via the overflow.

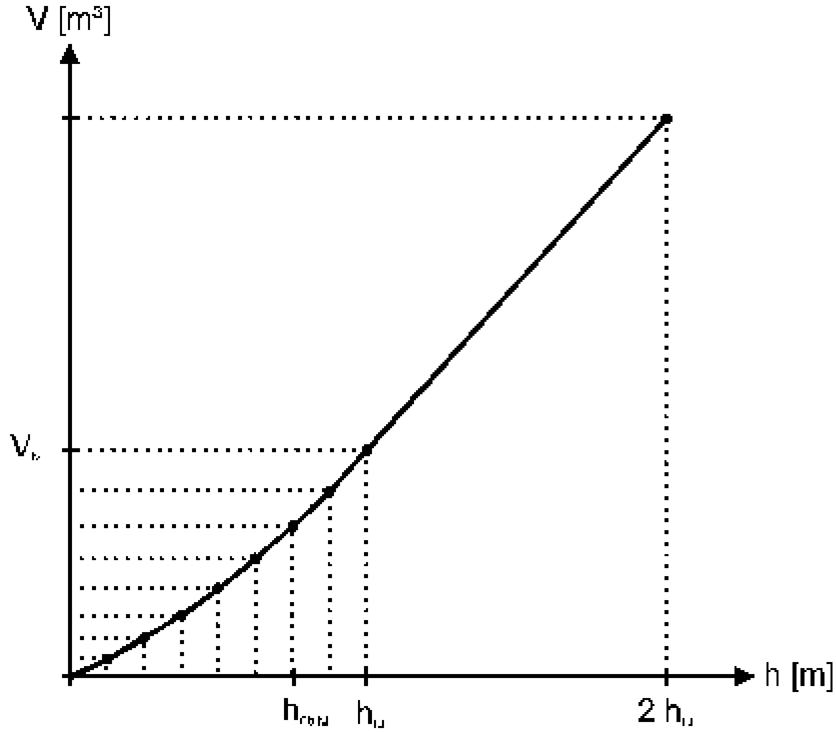


Figure 4-15: Volume curve for a swale in the shape of an obelisk

Inflow

The swale storage element receives its inflow from the surface discharge, determined for the existing connected surface types. The precipitation that falls into the swale is included in the simulation by classifying the swale area ($A_{s,M}$) as a discharge-effective surface. In the context of the runoff formation, the storage volume loss due to wetting storage h_b = 1 mm is also taken into consideration.

Discharge

Emptying of the swale occurs via three processes (see Figure 4-16):

- infiltration $Q_{V,M}$
- overflow $Q_{Ü,M}$
- evaporation $Q_{E,M}$

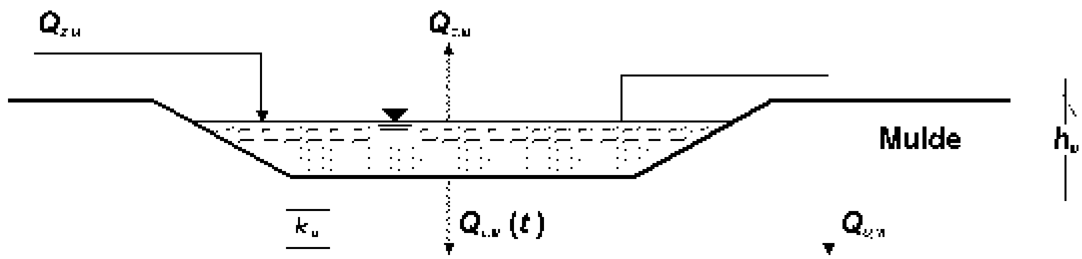


Figure 4-16: Swale flow scheme

The inviltration $Q_{V,M}$ from the trough, which supplies the trough bottom layer (ground storage) (see Figure 4-1), is calculated according to equation 4.35.

$$Q_{V,M} = \frac{k_{f,M}}{2} \bullet A_s(h) \bullet 1000 \qquad (4.35)$$

where kf,M = permeability coeffecient for the swale bed (m/s)

As (h) = infiltration-effective swale surface area (m²)

The infiltration-effective swale surface, which is calculated as a function of swale geometry for the respective water level *h* in the swale, corresponds to the changing free water surface in the swale. With the obelisk shape, these surfaces are rectangular. If the user wishes to use a swale geometrically different than the default "obelisk" shape, not only the volume characteristic function, but also the infiltration characteristic function must be defined. Figure 4-17 depicts an infiltration characteristic curve for an obelisk-shaped swale. By multiplying the area $A_s(h)$ with the permeability factor k_f (hydraulic conductivity) of the saturated soil zone (swale bed) (which, simplified, is half the hydraulic conductivity (viz. ATV A 138)), the infiltration capacity of each respective water level in the swale can be calculated according to Equation 4.35.

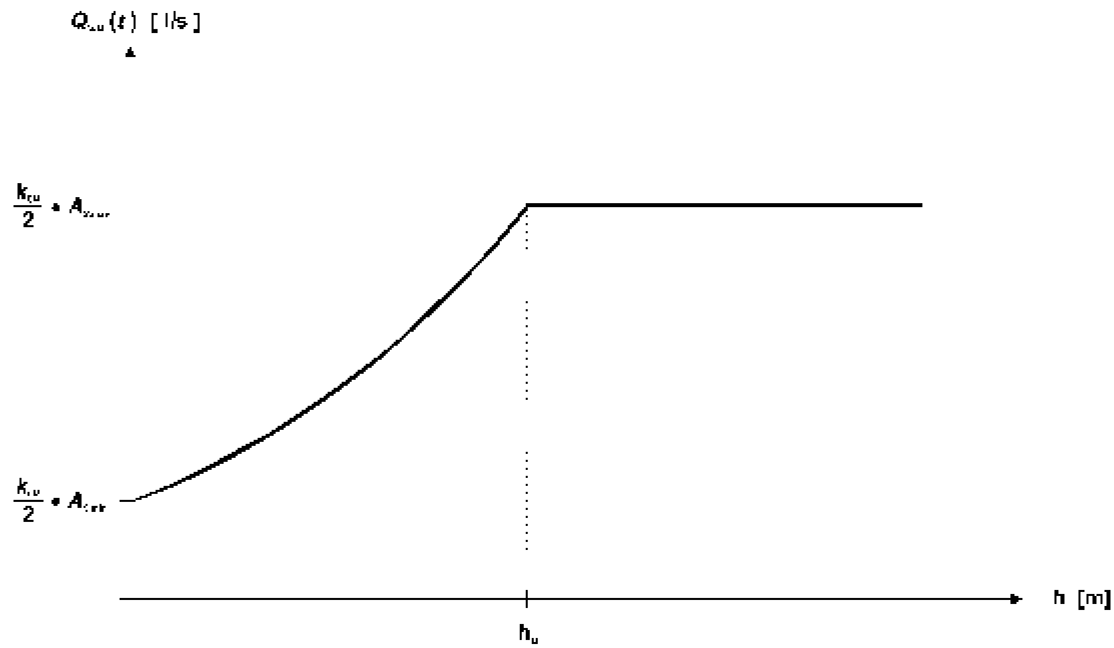


Figure 4-17: Infiltration curve for a swale

The infiltration capacity $Q_{V,M}$ reaches its maximum value when the swale is impounded (h=h_M), and kept constant at this value when inflow water stoppage occurs (h>h_M). In the long term, the bottom surface of the swale is regarded as effective for infiltration.

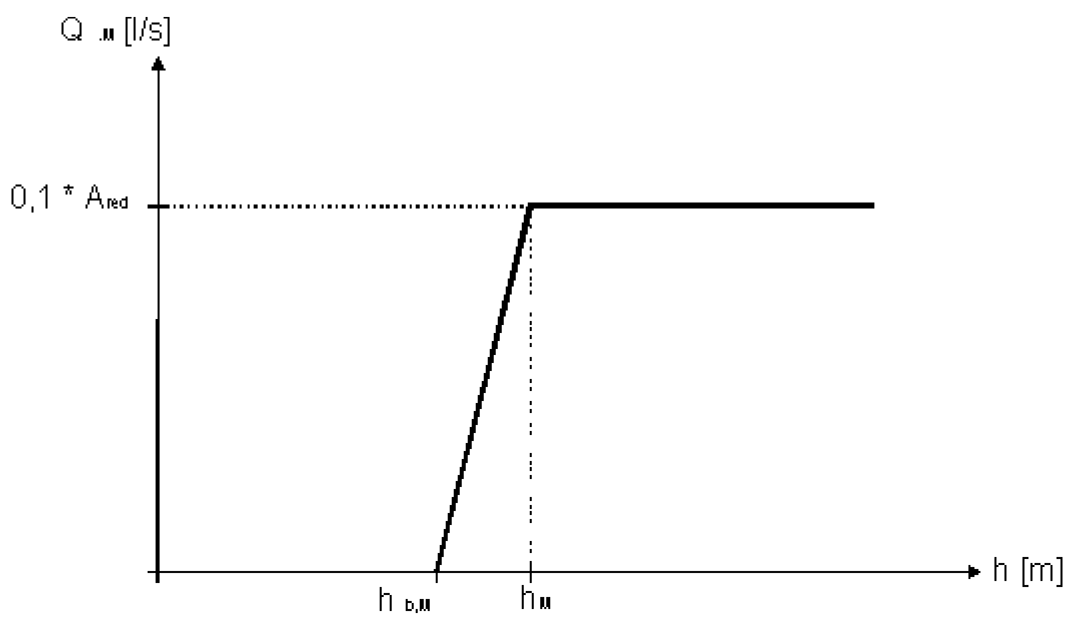


Figure 4-18: Overflow curve for a swale

The overflow $Q_{Ü,M}$ of the swale is described by a characteristic curve represented in Figure 4-18. The overflow routine commences when the maximum water level h_M of the swale is attained ($Q_{ü,M,max}$ at h_M + 0.1).

The maximum value of the overflow characteristic is calculated as the product of an area-based discharge loading of 0.1 l/(s · m^2) and the connected surface area A_{red}:

$$Q_{Ü,M,max} = 0{,}1 \bullet A_{red} \bullet 1000 \quad (l/s) \quad (4.36)$$

A high value of 0.1 l/(s · m^2) for the regionally based discharge intensity ensures that, in all cases, the overflow capacity $Q_{Ü,M}$ is larger than the expected inflow $Q_{Z,M}$ when the swale is impounded. Thus, the overflow volume in connection with the overflow frequency becomes the calculation criterion for a swale. Hence, additional impounding of water beyond the given swale volume is not possible.

The evaporation $Q_{E,M}$ from the swale is regarded as negative inflow. The calculation of the current evaporation occurs according to Section 4-2.

3.1.5.3 Swale Bed

The swale bed (ground storage) is a system element that characterises the processes in the swale bed- between the swale bottom and the top of the trench. The soil physical processes in the swale bed are modelled in a very simplified way. Retentions effects are reached through temporary storage and soil-specific infiltration and evaporation processes.

Geometry

The swale bed (ground storage) has the geometrical form of a block, whose horizontal expansion corresponds to the maximum infiltration-effective surface area A_S of the swale. Its thickness h_B is identical to the thickness of the bottom layer between the swale and the trench. The effective storage volume is calculated by means of the effective field capacity *eFK* of the soil as follows:

$$
\begin{aligned}
V_B &= A_{S,max} \bullet h'_B \\
&= A_{S,max} \bullet h_B \bullet \frac{nFK}{100}
\end{aligned}
\quad (4.37)
$$

where V_B = storage volume of the swale bed (m³) $A_{S,max}$ = maximum infiltration-effective area of the swale (m²)

h_B = thickness of the swale bed (m)

e*FC* = effective field capacity (%)

Using the effective field capacity *eFC* in Equation 4.37 to determine the swale bed storage volume complies with the physical condition that the filler-material underneath the swale bed has a porosity and k_f - value (units is m/s) which are both substantially higher than those of the swale bed soil. The total pore volume of the swale bed cannot be used for water storage, because the flow and gravitation potentials towards the trench are too large. In accordance with the definition of *eFC* only this water volume can be held back against the gravitation potential.

Discharge

The discharge from the trough bed (ground storage) consists of the components infiltration $Q_{V,B}$ and evaporation $Q_{E,B}$, as shown in Figure 4-19.

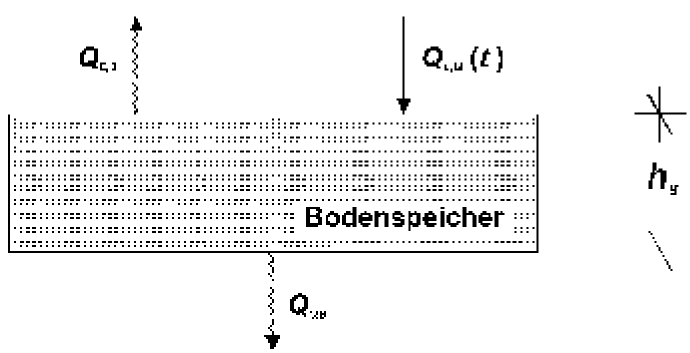


Figure 4-19: Ground storage flow scheme

The infiltration $Q_{V,B}$ of the swale bed is calculated according to the characteristic curve (Figure 4-20), which is a function of the water level. Referring to Figure 4-20, the infiltration from the swale bed begins only when the swale bed is half filled. The swale must contain a certain amount of water before discharge from the swale bed can occur. When the swale bed is completely filled, the water which seeps through the swale directly enters the trench. In order to limit the calculation time, the infiltration hydrograph at $h = 0.51 \cdot h_b$ is sharply inflected and runs steeply towards zero. This allows minimal infiltration rates and long computing times to be avoided. At the beginning of the long-term simulation the swale bed is assumed to be half full.

The maximum infiltration capacity of the swale bed corresponds to that of the swale.

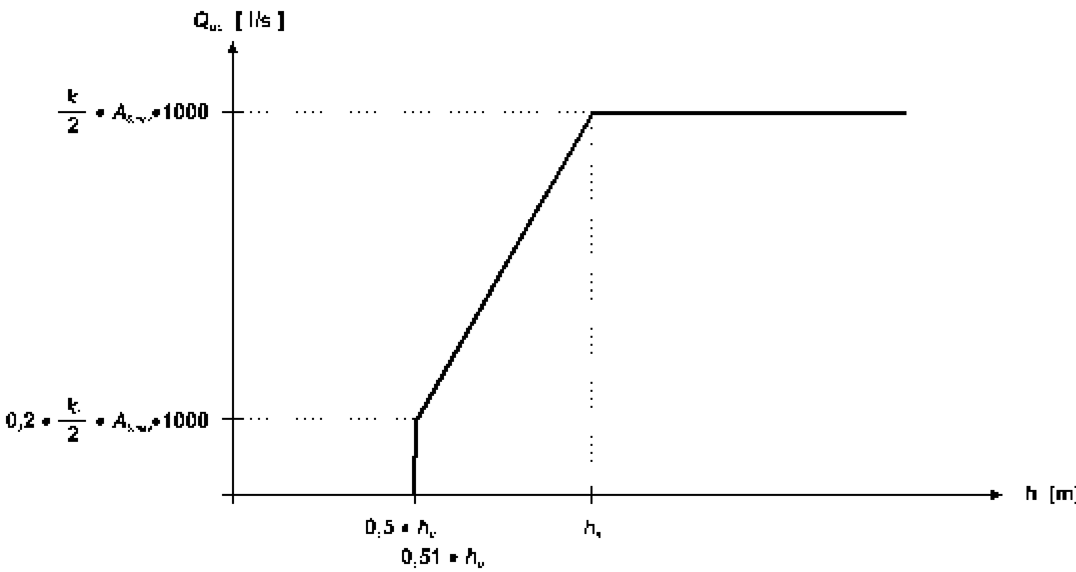


Figure 4-20: Infiltration characteristic curve for the ground storage

The evaporation QE,B is taken into account according to section 4–1.

3.1.5.4 Trench

Trenches aid the underground infiltration of stormwater even with less permeable soils. This is achieved through temporary storing the runoff in the pore volume of the filling material. The trench body is usually created from gravel (16/32 mm); other materials, however, such as lava pellets, can certainly be used.

With the swale-trench system, the trench is located underneath an infiltration swale. It absorbs the swale discharges infiltrating through the swale bed as well as swale overflows. The trench is emptied primarily through infiltration into the surrounding soil. In order to empty the trench in a reasonable amount of time, it is necessary with low Kf values to provide the trench with a bottom outlet. This is achieved by laying a drainpipe in the trench with a connection to a downstream drainage element. Additionally, trenches can be outfitted with an overflow.

With STORM©, trenches as a component of the swale-trench system, as well as simple trenches or pipe trenches can be dimensioned.

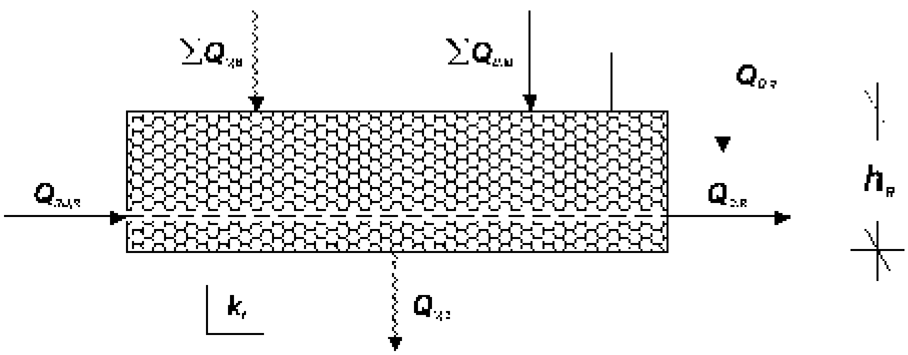


Figure 4-21: Trench flow scheme

Geometry

The default shape of trenches is a block, for which the storage volume can be calculated as follows:

$V_R(h) = l_R \bullet b_R \bullet h \bullet \hat{s}$ (4.38) where

$V_R(h)$ = trench storage volume (m³) l_R = trench length (m)
b_R = trench width (m)
h = water level within the trench (m)

$\hat{s}$ = replacement storage coefficient

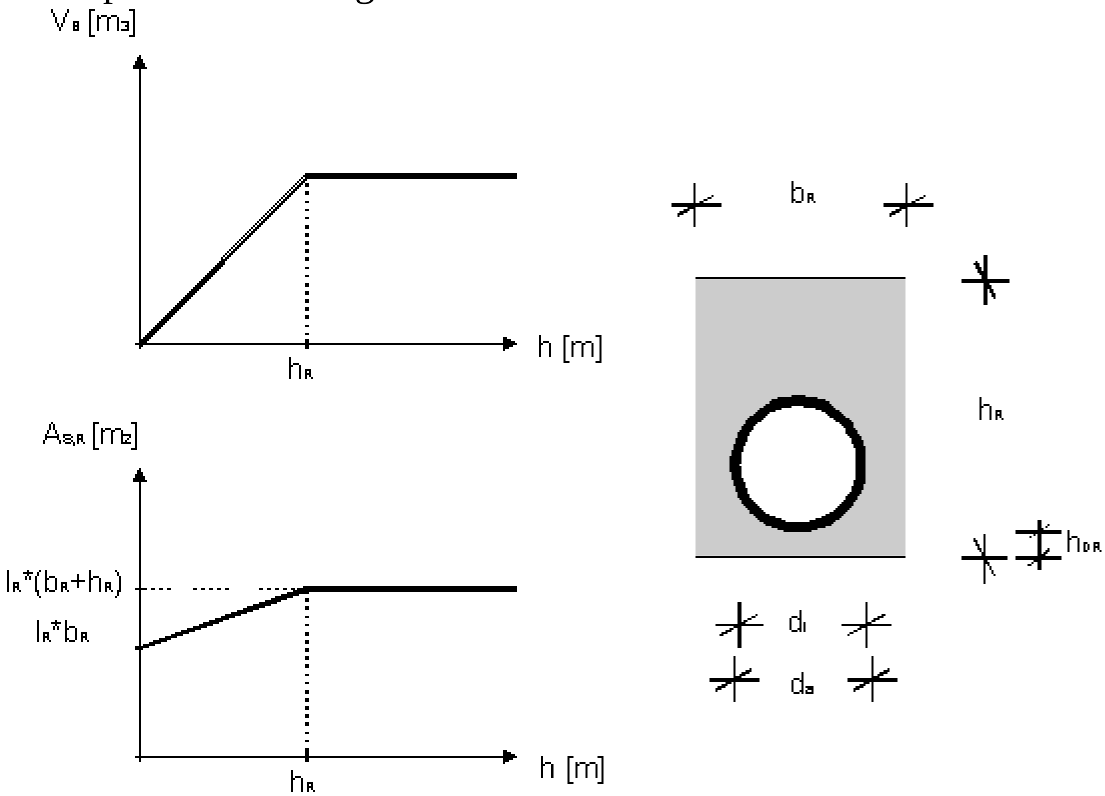


Figure 4-22: Geometric characteristic curves and cross-section for a trench with drainpipe

The replacement storage coefficient $\hat{s}$ in equation 4.38 incorporates both the porosity of the trench filler material using the material parameter *s* (storage coefficient) and the volume made available by the trench drainage pipe. The latter gains special importance when the pipe is of considerable diameter. The geometry (L_R , b_R, h_R) of the trench is available as default values in the tagged sheet “Dimensions“ in the dialog window “Properties Trenches“.

Referring to Figure 4-22, the replacement storage coefficient $\hat{s}$ can be found using the following equation:

$$\hat{s} = s + \frac{\pi}{4 \bullet b_R \bullet h_R}(d_i^2 - d_a^2) \quad (4.39)$$

where s = storage coefficient of the filler material (-)
d_i = inner diameter of the pipe (m)
d_a = outer diameter of the pipe (m)
b_R = trench width (m)
h_R = trench height (m)

Inflow
The inflow to the trench (see figure 4-21) is determined from the discharge from the upstream system elements. In the case of a networked swale-trench system, the inflow consists of the following components:

- in certain cases, the discharge from the overlying trench $Q_{Z,R}$,
- the total infiltration rates of the attached trough bed $Q_{V,B}$, and
- the total overflows of the connected troughs $Q_{Ü,M}$.

Discharge
The discharge from the storage element "trench" results from the following:

- throttle discharge $Q_{D,R}$,
- infiltration from the trench $Q_{V,R}$ and
- trench overflow $Q_{Ü,R}$.

The maximum throttle discharge $Q_{D,R}$ (h_R of the trench is calculated from a global regional throttling variable q_D (l / (s * ha)):

$$Q_{D,R}(h_R) = \left(\sum_i A^i_{red}\right) \bullet q_D \bullet 10^{-4} \qquad (4.40)$$

where $Q_{D,R}$= throttle discharge (l/s)
h_R = maximum water level of the trench (m)
q_D = regional throttling variable (l / (s * ha))
i = index of the upstream connected trench (-)
A_{red} = discharge-effective surface area of connected trench i (m²)

According to Equation 4.40 the throttle discharge is calculated by taking the product of the total discharge-effective surface areas connected to the trench and the regional throttling variable q_D. The area-based discharge loading q_D

is a program global variable, with which the discharge from the trough-trench system is determined. This computational method ensures that a fully impounded trench does not cause the throttle outflow of an upstream trench to overflow. An option is provided, where the throttle discharge can be given directly as input.

A throttle characteristic curve is shown in Figure 4-23. The maximum throttle discharge is achieved only when the trench is completely filled. The automatic calculation of the throttle discharge in STORM© takes the linkages between the trench elements into consideration.

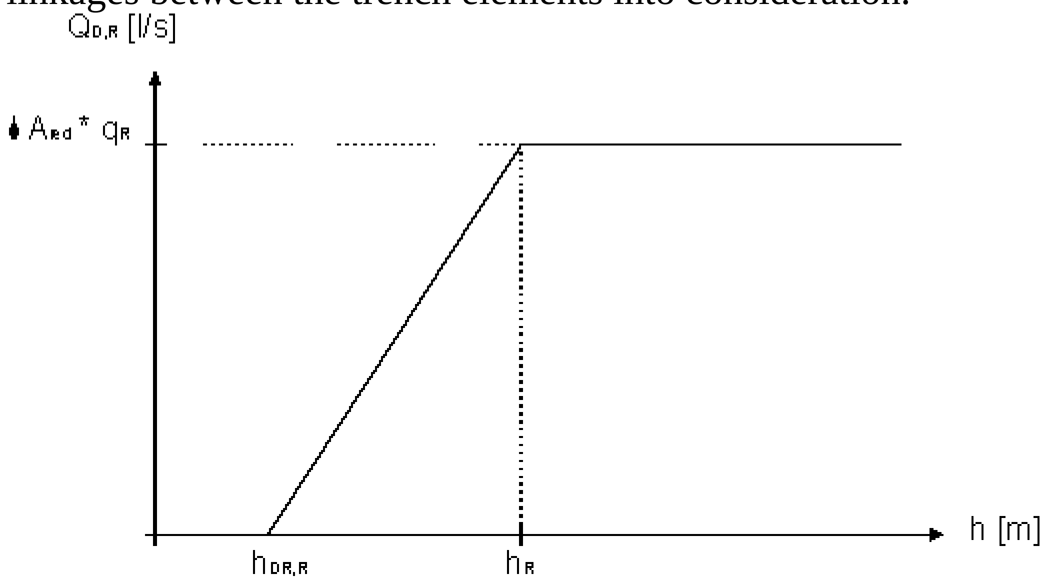


Figure 4-23: Trench throttle curve

The infiltration capacity $Q_{V,R}$ of the trench is calculated by:

$$Q_{V,R}(h) = A_{s,R}(h) \bullet \frac{k_f}{2} \bullet 1000 \quad (4.41)$$

where $Q_{V,R}(h)$ = infiltration capacity (l/s)

$A_{s,R}(h)$ = infiltration-effective surface area of the trench (m²)

k_f = permeability coefficient of the surrounding soil (m/s)

h = water level in the trench (m)

In accordance with the German guidelines ATV A138, the k_f -value of the surrounding soil is reduced by a factor of 0.5. The same guidelines also consider only half of the vertical sides of the trench as effective for infiltration when the trench is completely filled with water. The top face of the trench body remains unconsidered and it is assumed that the trench bottom, in the long term, remains effective for infiltration. The infiltration-effective surface area $A_{S,R}(h)$ becomes:

$$A_{s,R}(h) = l_R \bullet \left(b_R + 2 \bullet \frac{h}{2}\right) \quad (4.42)$$

where $A_{s,R}(h)$ = infiltration-effective surface area of the trench (m²)
l_R = trench length (m)
b_R = trench width (m)
h = water level in the trench (m)

The throttle, overflow, infiltration and volume characteristic curves of the trench can be modified by the user, so that different trench shapes may be modeled.
If the element connected to the trench downstream is a connection pipe, the overflow $Q_{Ü,R}$ of the trench is limited by the maximum discharge capacity of the off-flow connecting pipe. Q_{max} is the maximum possible overflow and is taken as the difference between the discharge when the connecting pipe is completely water-filled and the maximum throttle discharge $Q_{D,R}$ (see equation 4.40). The calculation of the discharge of the off-flow connecting pipe is according to Toricelli. By equating the sum of the maximum throttle discharge of the trench $Q_{D,R}$ with the maximum overflow capacity Q_{max} and solving for Q_{max} gives:

$$Q_{A,max}\ (h = h_R) = \mu \bullet A_Q \bullet \sqrt{2 \bullet g \bullet \left(h_R + \frac{h_R}{20}\right)} \bullet 1000 - Q_{D,R} \quad (4.43)$$

where $Q_{A,max}$ = maximum trench overflow (l/s)
$Q_{D,R}$ = maximum throttle discharge of the trench (l/s)
h_R = height of the trench body (m)
A_Q = cross-sectional area of the connecting pipe (m²)
g = gravitational acceleration (9.81 m/s²)
μ = runoff coefficient = 0.7 (-)

Alternatively, the max. overflow capacity for the trench can be input manually.
When inputting data, as with other storage elements, overflow hight is distinguished from depth. The overflow hight is the value at which the

overflow switches on. The overflow $Q_{Üb,R}$ of the trench is depicted by a characteristic curve (Figure 4-24).

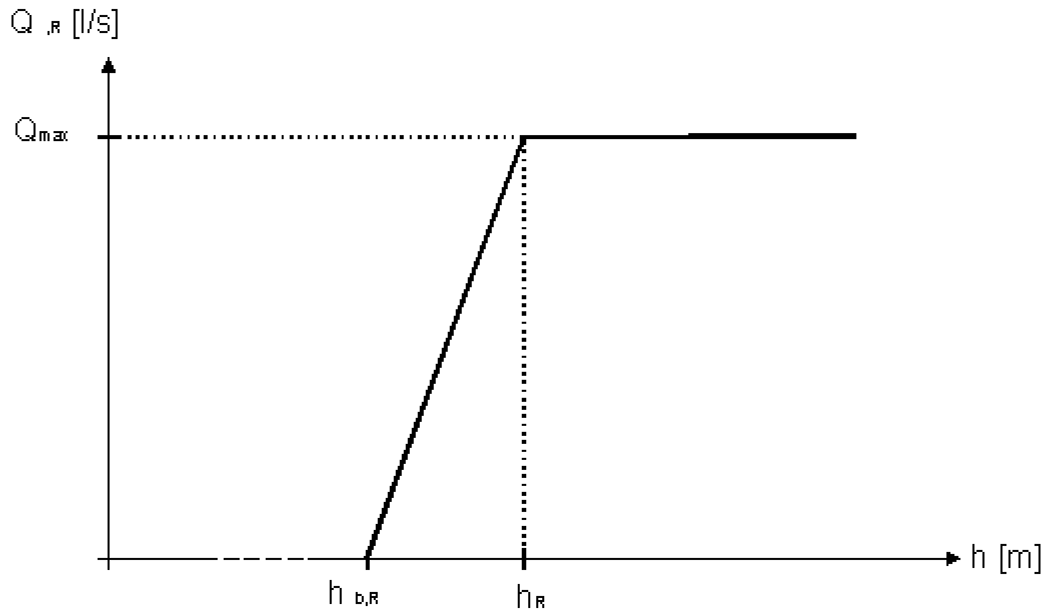


Figure 4-24: Overflow characteristic curve for a trench

Hence, only when the water level exceeds the height of the trench (h_R) does the overflow take effect, which very rapidly achieves its maximum value.

Due to the limitation of the overflow capacity (Q_{max}) (see equation 4.43), numerically a volume can adjust to the impound volume of the trench, which is larger than the trench storage volume. From the described computational procedure and the use of the standard characteristic curves as calculation criterion, the total volume becomes the sum of the impounded and overflow volumes and the overflow frequency of the trench.

3.1.5.5 Swale-Trench Element, Innodrain©

The swale-trench element and the Innodrain© system represent a combination of swales and trenches. Therefore they need not be further explained here.

Generally infiltration from the swale is led into the underlying trench. The overflow is also adjusted to the standard.

3.1.5.6 Green Roof

The green roof is, just like the swale-trench element and Innodrain©, a combination of "swale" and "trench".
The substrate layer should be treated as a swale, however, one that has no impound volume. The water storage occurs via the adjustable usable field capacity. A pre-saturation can be set. The Kf-value of the substrate layer is, at 10'-3 m/s, considerably higher than that of topsoil.
The infiltration and the overflow from the substrate layer occur in the drainage layer. The overflow destination can be set, however.
The drainage layer is similar to the function of the trench. In contrast however, only a throttled discharge or an overflow occurs. Infiltration from the drainage layer is not intended.
Due to the fact that roofs are often very different from one another, general parameter defaults for simulating a roof cannot be compiled. The deciding factor is the discharge throttle from the drainage layer. Here it makes sense to calibrate the model to the roof beforehand on the basis of measurements.

3.1.5.7 Stormwater Retention Tanks

Stormwater retention tanks serve to dampen the runoff in a separated system. Infiltration generally does not occur in these facilities. Stormwater retention tanks can be used separately as central or semi-central drainage elements or in combination with on-site stormwater management measures. Stormwater retention tanks are modelled as a storage element with an inflow, a throttled discharge, and an overflow (see figure 4-25)

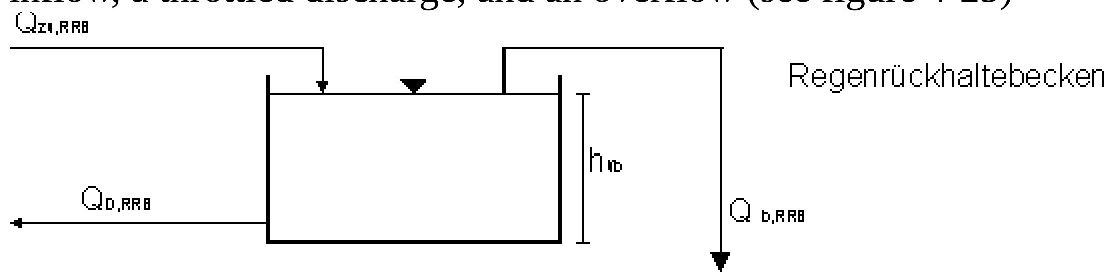


Figure 4-25 Flow scheme for stormwater retention tanks

Geometry

The default shape of stormwater retention tanks is an obelisk (see swale geometry, Figure 4-14) block. The storage volume can be calculated from equation 4.34.

The volume characteristic curve (see figure 4-26) is automatically created in STORM© with 3 pairs of values.

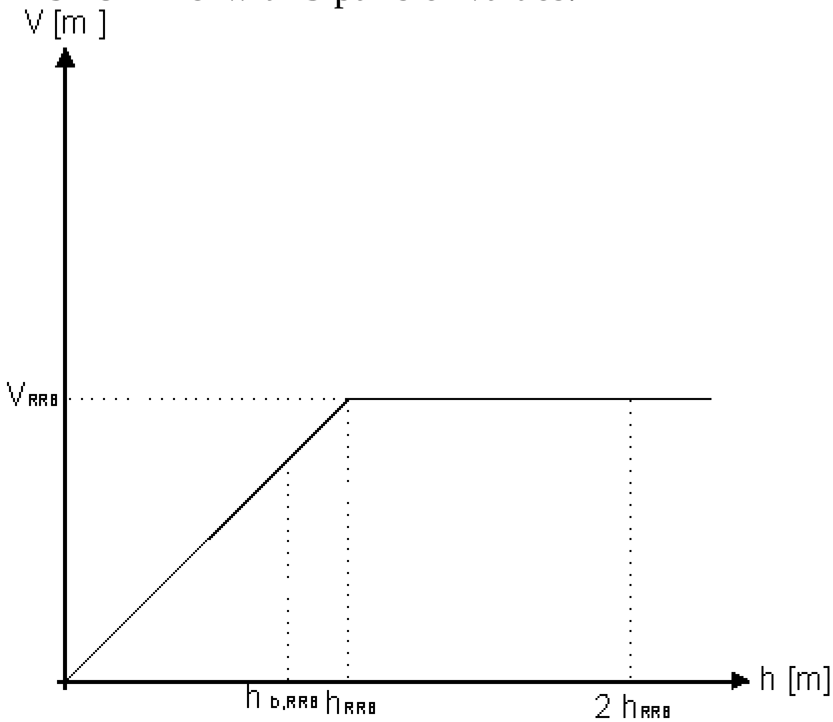


Figure 4-26 Volume characteristic curve for stormwater retention tanks

Inflow

The inflow to the stormwater retention tank is calculated from the runoff formation calculation of the assigned surfaces or the discharge from the upstream drainage elements (see figure 4-25, QZU). If the volume tank is exhausted, the inflow is sent to the assigned downstream drainage element (such as an infiltration swale) as overflow.

Discharge

The discharge from stormwater retention tanks consists of:

- Throttle discharge $Q_{D,RRB}$,
- Tank overflow $Q_{Ü,RRB}$.

The maximum throttle discharge$Q_{D,RRB}$ (h_{RRB}) for the tank is calculated with the regional throttling variable q_D (l/(s·haAred)):

$$Q_{D,RRB}(h_{RRB}) = \left(\sum_i A^i_{red}\right) \bullet q_D \bullet 10^{-4} \qquad (4.44)$$

where $Q_{D,R}$ = throttled discharge (l/s)

h_R = maximum water level in tank (m)

q_D = regional throttling variable (l/(s·haAred))

A_{red} = surface area connected to the tank (m²)

The throttled discharge according to equation 4.44 is calculated from the product of the upstream connected surface area with the regional throttling variable q_D. The discharge loading rate q_D is value to be set with which the discharge from the system is determined. This approach ensures that when the tank is fully impounded, the throttled runoff from an upstream drainage element cannot lead to overflows. Optionally, the max. throttled discharge can, however, also be directly input for each stormwater retention tank. Furthermore, there is the possibility to input a minimum throttled discharge (i.e. when h=0).

The progression of the throttle characteristic curve can be seen in figure 4-23. The maximum throttled runoff is only reached when the tank is completely filled.

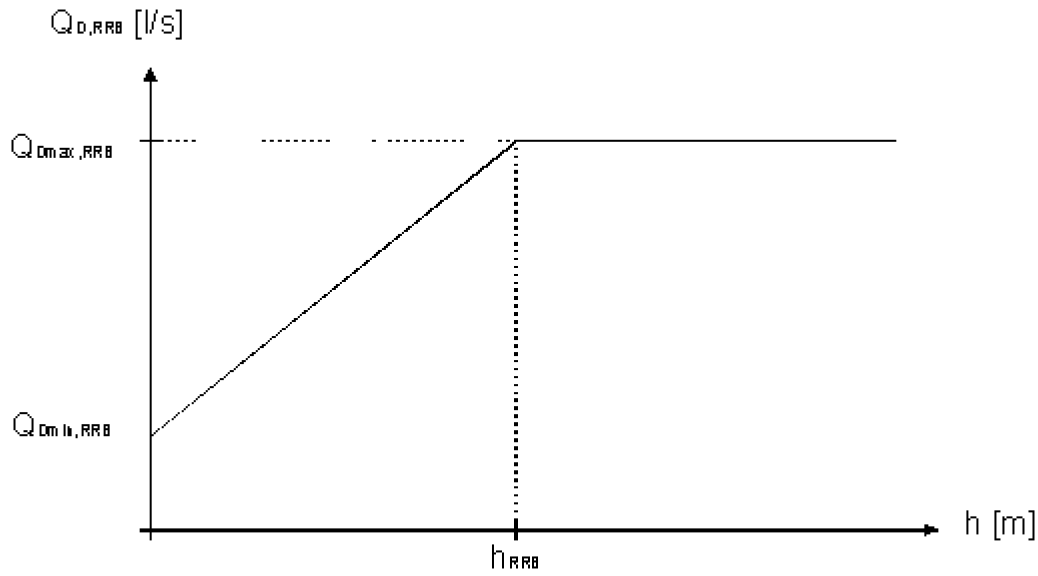


Figure 4-27: Throttle characteristic curve for stormwater retention tanks

The overflow QÜ,RRB of the tank is depicted by a characteristic curve (figure 4-28). The overflow turns on when the overflow hight hüb,RRB is reached, and reaches its maximum Qübmax,RRB at the tank depth hRRB. The maximum value for the overflow curve Qübmax,RRB must be indicated. The value should be selected so that, in every case, the overflow capacity QÜmax,RRB is larger than the inflow to be expected QZU,RRB when the tank is impounded. So, the overflow volume, in conjunction with the overflow frequency is a dimensioning criterium for a stormwater retention tank. Large amounts of water cannot impound beyond the given tank volume.

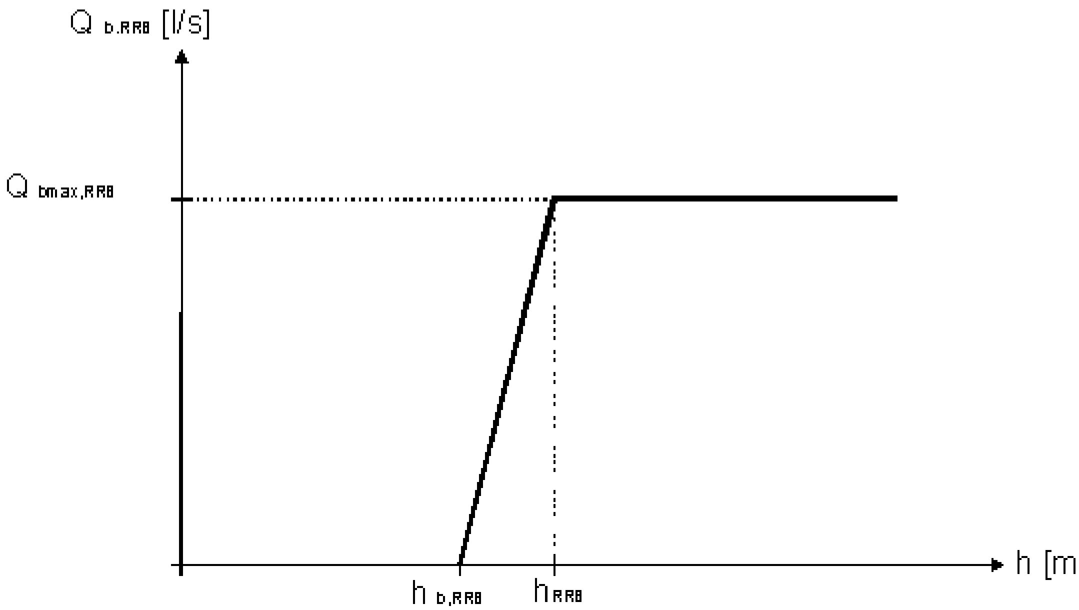


Figure 4-28 Overflow characteristic curve for stormwater retention tanks

3.1.5.8 Stormwater Sedimentation Tanks

Stormwater sedimentation tanks are calculated similarly to a stormwater retention tank. There is, however, no evaporation to be considered since it is a closed system. The sedimentation behaviour for substances is taken into account through pre-defined parameters. In contrast to stormwater retention tanks, data about the pollution load and concentrations are output.

3.1.5.9 Retention Tanks

A retention tank has a throttled discharge and a tank overflow. The tank overflow is located before the tank.

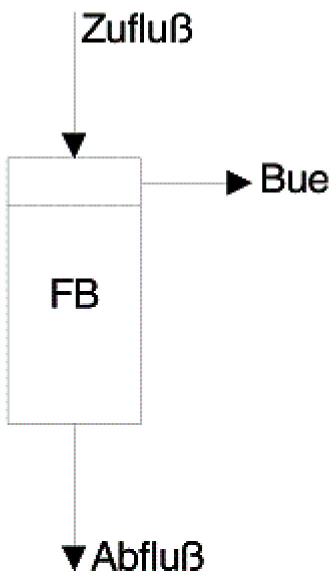


Figure 4-29: Retention Tank

3.1.5.10 Throughflow Tanks

A throughflow tank also has a treated overflow.
The treated overflow is located in the tank area and releases partially treated sewage. The treated overflow capacity is generally limited.

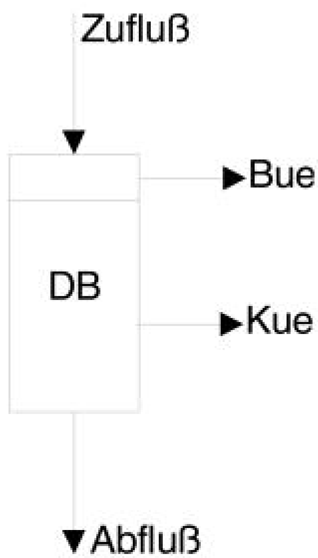


Figure 4-30: Throughflow tank

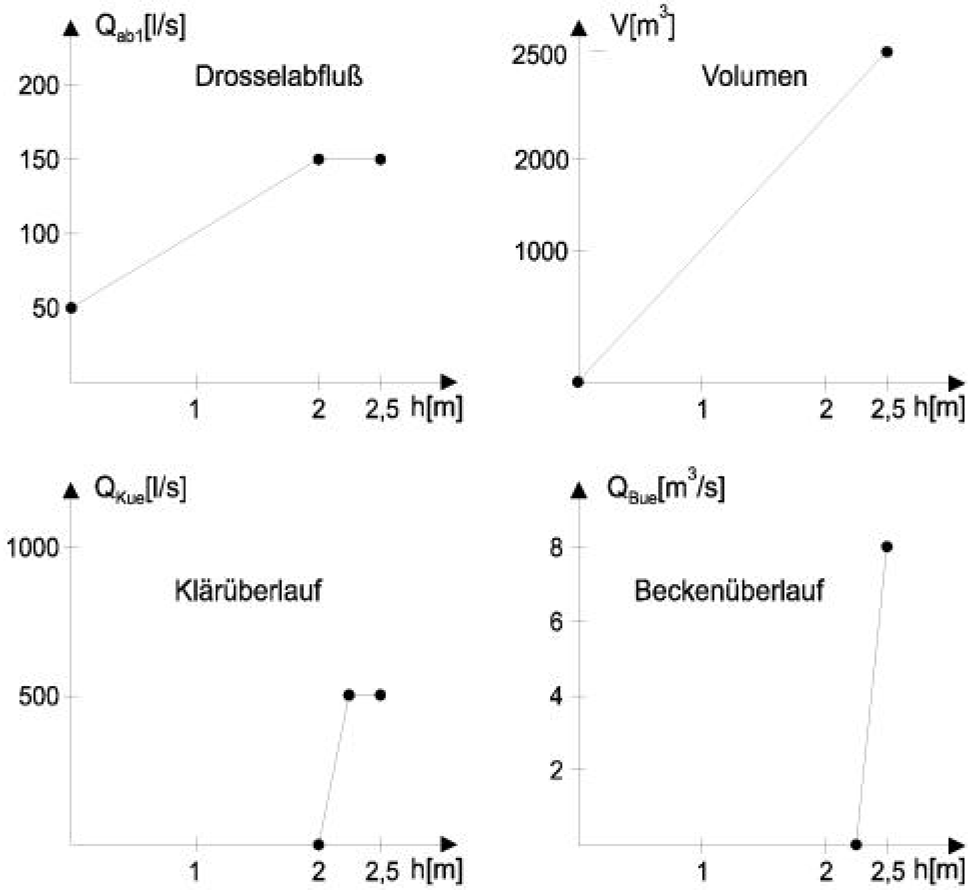


Abbildung 4-31: Kennlinien eines Durchlaufbeckens

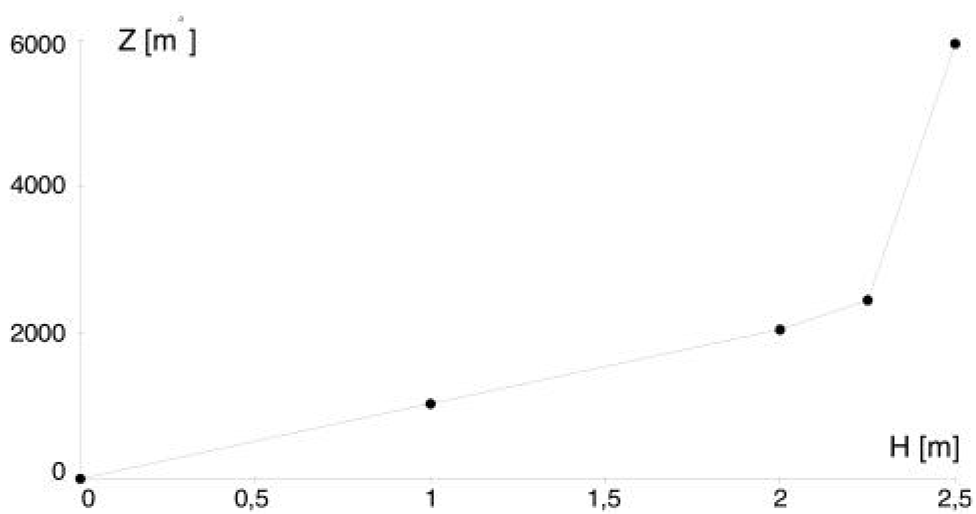


Figure 4-32: Function of a throughflow tank

Stormwater tanks and throughflow tanks can be arranged

- online and
- in bypass,

which, however, is of importance for the pollution load calculation. In Worksheet A 128, instructions are given for the form and arrangement of tanks. The characteristic curves are generated for rectangular tanks in STORMİ.

3.1.5.11 Sewers with Storage Capacity

Sewers with storage capacity have special shapes.

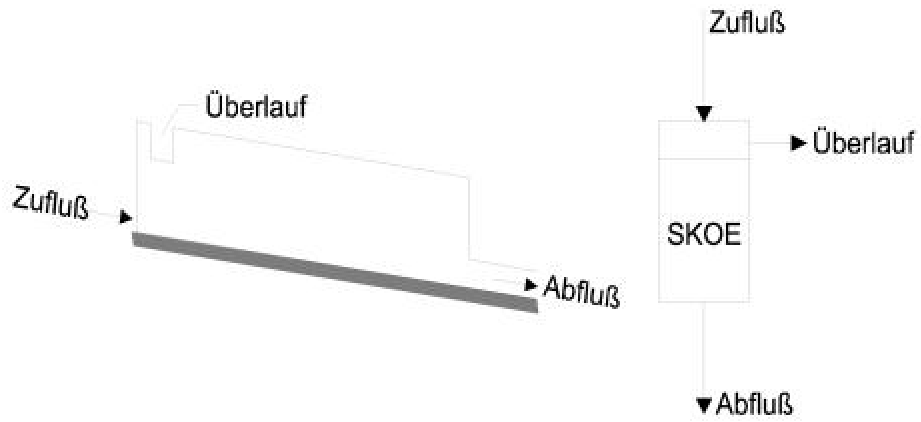


Figure 4-33: Sewer with storage capacity with overlying release

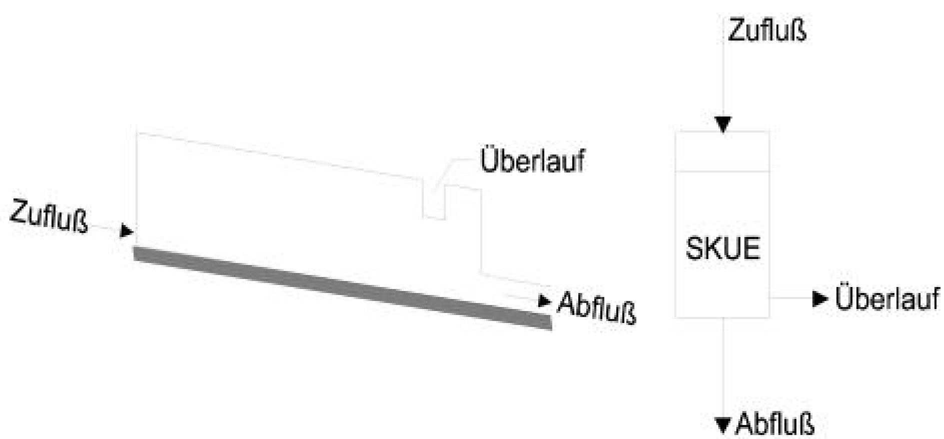


Figure 4-34: Sewer with storage capacity with underlying release

Technically, in the model, a sewer with storage capacity with overlying release is described as an online retention tank, and a sewer with storage capacity with underlying release is described as an online throughflow tank. In STORM©, sewers with storage capacity can be explicitly taken into account können Stauraumkanäle explizit berücksichtigt werden. Characteristic curves can be automatically generated for

- Egg-shaped,
- Circular,

- and Mole

cross-sections.

3.1.5.12 Storage Calculation

The hydrological functions of the storage elements (cisterns, swales, trenches, stormwater retention tanks) has been explained in the previous sections. For calculating the hydraulic functions (storage) it is required that

- the inflow hydrograph for each particular storage element is not influenced by the water level in the storage and
- the water level in the storage is constantly horizontal and therefore there are no flow processes to be taken into account in the storage.

These requirements are mentioned rather for reasons of integrity since they are not relevent for the storage elements due to their size. This way, the storage calculation can be reduced to balancing the volumes, although the continuity must be aussured. Damit lässt sich die Speicherberechnung auf eine Bilanzierung von Volumina reduzieren, wobei die Kontinuität gewahrt sein muss. The following must hold true: Storage change = Inflow – Discharge

For the storage elements, it must be considered during storage calculation that the discharges can change as a function of the storage filling within a time step Dt. The particular discharge components are described by characterstic curves (see Sections 4.5.2 to 4.7). In detail, the following relationships must be known:

for cisterns:

VZ = f(h) storage volume

Qü,Z = f(h) overflow

Qe = const. withdrawal

for swales:

VM = f(h) storage volume

As = f(h) infiltration-effective surface area Qü,M = f(h) overflow

in swale bed:

VB = f(h) storage volume

QV,B = f(h) infiltration rate

for trenches:

VR = f(h) storage volume

QD = f(h) throttled discharge

As = f(h) infiltration-effective surface area Qü,R = f(h) overflow

for stormwater retention tanks: VRRB = f(h) storage volume
QD = f(h) throttled discharge
Qü,RRB = f(h) overflow
For the swales and trenches, by multiplying with each particular soil permeability kf, one can form a characteristic curve for the infiltration rate Qs = f(h) from the curve for infiltration-effective surface As = f(h) so that the discharge-based curves show the same units (e.g. l/s) and can be integrated linearly to a characteristic curve Qab = f(h). As an example for a trench:

$$Q_{ab}(h) = A_s(h) \bullet \frac{k_f}{2} + Q_D(h) + Q_{\ddot{u},R}(h)$$ (4.45) The geometric ratios are described by a V = f (h) curve.

In the scope of the storage calculation, the storage elements are treated completely identically. Merely the characteristic curves are different. Of course, the inflow hydrographs are also different.
The following continuity precondition forms a basis for simulating the filling and emptying processes in these storage elements:

$$V_t = V_{t-1} + \left(Q_{zu,t} - Q_{ab,t}\right) \bullet \Delta t$$ (4.46)

where Vt = stored volume
Qzu,t = inflow at time t Qab,t5 = discharge as time t Dt = calculation timestep If you switch equation 4.46 around so that the known values are on the right side and the unknowns are on the left, you get:

$$V_t + Q_{ab,t} \bullet \Delta t = V_{t-1} + Q_{zu,t} \bullet \Delta t$$ (4.47)

Since the stored volume V, as well as the discharge Qab, is known from the storage as a function of the water level in that storage, the left side of equation 4.47 can be integrated in a substitute function Z:

$$Z = \mathrm{f}(h) = V_t + Q_{ab,t} \bullet \Delta t$$ (4.48) This new curve Z = f (h) can be determined in advance with the curves for V (h) and Qab (h) and draw on the water level in the scope of the storage calculation. The process of storage calculation has been developed by VERWORN (1986) as whole-step-approach for stormwater retention tanks.

3.1.6 Stormwater Overflows and Branchings

One of the differences between stormwater overflows and branchings is that with branchings, all flows remain in the system, while with stormwater overflows, a release into a river or stream generally occurs.

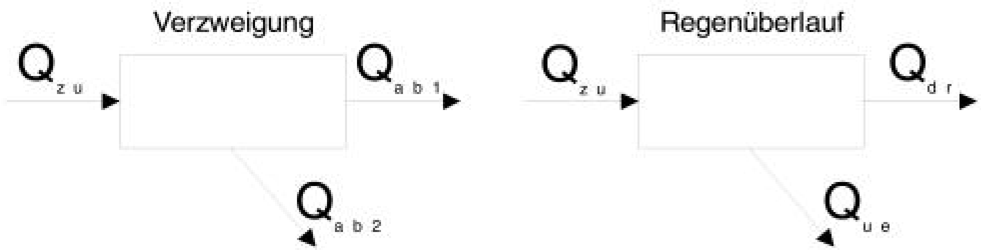


Figure 4-35: Flow scheme for a branching / stormwater overflow

3.1.6.1 Inflow-dependent Discharge Calculation

The calculation is the same in both cases. By inputting a function relationship between inflow and a discharge amount,

$Q_{ab,1} = f(Q_{zu})$ (4.49)

$Q_{ab,2} = Q_{zu} - Q_{ab,1}$ (4.50)

a discharge amount can initially be determined. The second discharge is determined from the difference between inflow and calculated discharge amount.

The function relationship is called a characteristic curve.

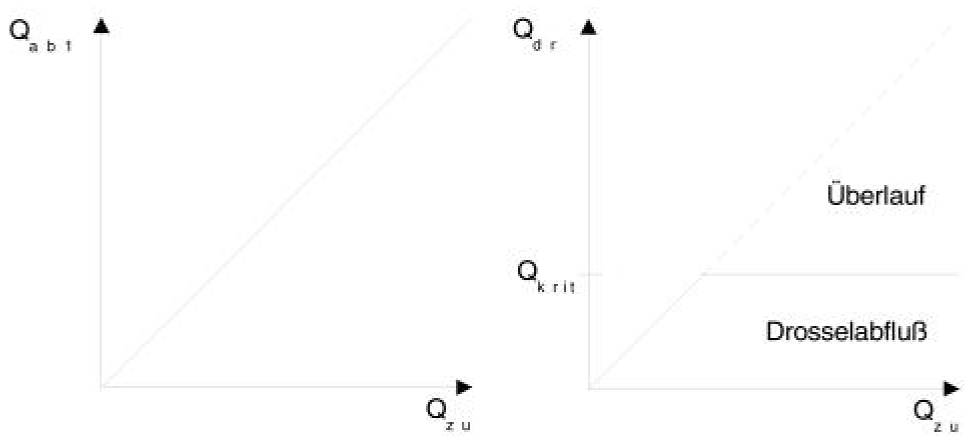


Figure 4-36: Geometric characteristic curve

In STORMİ, curves can be directly input, but there is also the possibilty to generate curves automatically with the help of parameters.

3.1.6.2 Branchings

Splitting runoff in branching structures often occurs via the hydraulic capacity of the continuative collectors. The split can occur via a procent indication, especially whenever both wasteways have the same bottom.

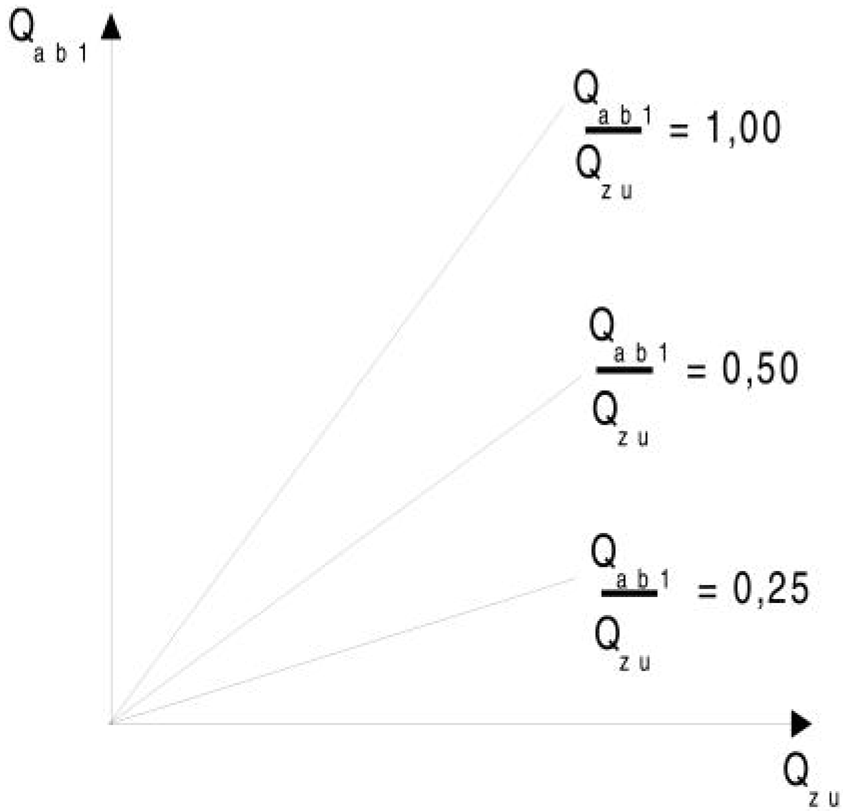


Figure 4-37: Geometric curves for a branching structure

The split always happens with the same proportions independent of the current inflow. The branching curve can be changed by the user. This way, any configuration, e.g. even thresholds within the system, is possible.

3.1.6.3 Stormwater Overflows

The function of a stormwater overflow can be depicted with a threshold value model. Until a threshold value Qkrit is reached, the throttled discharge corresponds to the inflow. Only when the critical inflow is reached does the overflow switch on. In greater approximation, it is assumed that the throttled discharge does not increase to more than Qkrit.

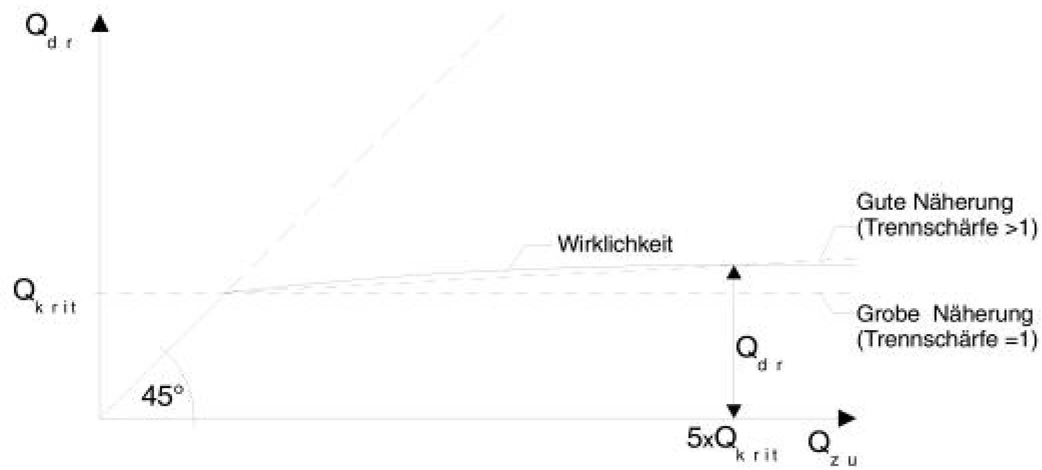


Figure 4-38: Distribution characteristic for stormwater overflows

In reality, however, a known increase of the throttled discharge does occur. To account for this effect, the separation effect is introduced.

$$Trennschärfe = \frac{Q_{ab}\,(Q_{zu} = 5 \bullet Q_{krit})}{Q_{krit}} \qquad (4.51)$$

The separation effect indicates the increase of the throttled discharge with an inflow of 5*Qkrit. A separation effect of 1 means that no increase is being accounted for. A separation effect of 1.1 corresponds to a 10% increase.

3.1.7 Connecting Pipes

In Version 2.1 of STORM©, connecting pipes served to connect trenches. Because of the newly developed programme structure, this type of connection is no longer necessary. Trenches can, for example, drain directly into downstream drainage elements.

As in the older versions, connecting pipes can cause a temporal delay of the discharge (translation). This way it is possible to consider the flowtimes between the system elements during the simulation process.

The discharges of the storage elements are passed on by translation to downstream system elements. The dynamics of the flow processes within the connecting pipes are neglected. At each time step, STORM© computes in such a manner, that all discharges are free-flowing and there is no blockage of water. The temporal delays, which arise from the flow processes between the trenches, can be calculated using the flow travel time (Prantl-Colebrook), which is a function of connecting pipe length and the flow velocity. The required downward slope of the connecting pipe is calculated by means of the trench bottom heights (above sea level). If no trench bottom heights are present in the system file (*.MRS), a minimum slope of 1% is assumed.

The downward slope of the pipes can be given as input by the user. With help of the geometrical dimensions and operational roughness, the flow travel time t_f according to Prantl-Colebrook can be determined from:

$$t_f = \frac{L}{-2{,}0 \bullet lg\left(\frac{2{,}51 \bullet \nu}{D \bullet \sqrt{2 \bullet g \bullet D \bullet I}} + \frac{k_B}{3{,}71 \bullet D}\right) \bullet \sqrt{2 \bullet g \bullet D \bullet I}} \qquad (4.52)$$

where L = length of the connecting element k (m)
D = diameter of the connecting element k (m) l = slope of the connecting element k (-) g = gravitational acceleration (» 9,81 m/s²) kB = operational

roughness (-)
n = kinematic (1,31·10-6 m^2/s)

3.1.8 Elements to Account for Discharges

Along with the previously mentioned system elements, there are system elements that serve to account for the discharges:

- Groundwater
- Rivers/Streams
- System Outlet

These elements can be selected as a drainage destination; i.e. the discharges or overflows from other elements are led to them. This is how, for example, infiltration volumes are generally led from trenches into the groundwater element. Here it is a simple possibility to create a water cycle for the entire system. Within these elements, no changes to the discharge takes place.

3.1.9 Discharge Hydrograph Elements

Discharge hydrograph elements serve to output water discharge time series. These elements can be placed at any point on the system between two elements.

3.2.1 Pre-dimensioning

The simulation model STORMę enables pre-dimensioning for cisterns, swales, trenches and stormwater retention tanks. The pre-dimensioning serves to determine the initial values for the required storage volumes. These input values are required for a long-term continuum simulation with STORMę. This pre-dimensioning step can be omitted if empirical values are available or the design specifications for the drainage concept (e.g. space available) are given, which enable the storage volumes of the system elements to be determined.

Pre-dimensioning is not only for computing the input values for a networked on-site stormwater management system. The programme also allows the dimensioning of single on-site facilities (swales and trenches) according to the German guidlines ATV-DVWK A138 (ATV-DVWK 2002) or, for stormwater retention tanks, according to ATV-DVWK A117 (ATV-DVWK 2000).

3.2.1.1 Design Storms/Heavy Rain Statistics

For dimensioning with design storms according to Reinhold, the runoff for a 1-year, 15-minute storm is necessary for each particular location. The runoff for the dimensioning frequency indicated in the elements is automatically calculated.

Dimensioning according to heavy rain statistics can occur by inputting the data for the corresponding location from the KOSTRA-Atlas of the German Weather Service (locations within Germany only). Alternatively, the location can be selected from a graphic. When choosing the location from the graphic, the corresponding average rain totals for the 1- or 100-year rain and the duration levels 15 min, 60 min, and 12, 24, 48, and 72 hours are entered in the table and the rain totals appropriate for the remaining duration levels and frequencies are determined. The data should be checked against the data from the KOSTRA-Atlas.

For calculating the hight of precipitation, 3 groups of duration levels are designated: Group I (5-60 min), Group II (60 min – 12h) and Group III (24-72h).

3.2.1.2 Cisterns

Cisterns can be pre-dimensioned in STORMİ according to a method by WILHELM. At the same time, the rainwater needs, which arise from the actual use, are contrasted with the rainwater yield.
The rainwater yield (RE) is determined from the connected roof surface area and the yearly hight of precipitation.
It is calculated by the following equation:
$RE = A_{red} \bullet \psi \bullet h_n \bullet 0.001$ (5.1) where RE = rainwater yield (m³)
Ared = connected surface area (m²)
y = average runoff coefficient(-)
hn = average yearly precipitation (mm/a)
The runoff coefficient conforms to the type of roof and can be approximated as 0.75 for steep roofs and 0.6 for flat roofs (WILHELM et al.).
The required storage size for the cistern is determined by means of statisticly calculated average values as a portion of the rainwater yield from the ratio of rainwater yield (RE) to rainwater use (RB). The average values are based on the recognition that the availability of rainwater with a large storage grows only insignificantly starting at a certain size. With the intended process, rainwater needs are covered on average by 90%.
The following equations depict the process for calculating the storage needs.
RE/RB < 0,5 Warning, rain yield is too low 0,5 <= RE/RB < 0,8 VCistern = 0,03*RE
0,8 <= RE/RB < 0,95 Interpolate VZisterne
0,95 <= RE/RB < 1,05 VCistern = 0,05*RE
1,05 <= RE/RB < 1,20 Interpolate VCistern
1,2 <= RE/RB VCistern = 0,03*RE
The following realisations should be deduced:
For a small rainwater yield, a smaller storage is needed than with a higher rainwater yield. If the rainwater yield is 20% smaller than the rainwater needs, a storage larger than 3% of the rainwater yield would never be completely utilised.
If the rainwater yield is larger than the rainwater needs by 20%, a smaller storage can likewise be used since the storage will be refilled frequently by

frequent precipitation. Larger amounts of water should not be held for long periods of time.

3.2.1.3 Swales

Pre-dimensioning swales in STORM© follows the German guidelines ATV A138 (ATV 1990). During pre-dimensioning each swale is treated as a single decentralised component.

Assuming a constant infiltration capacity the swale volume is calculated by taking the difference between the volumes of precipitation and infiltration. The precipitation volume equals the swale inflow $Q_{z,M}$ and is calculated using the discharge-effective surface and a site-specific regionally based rain intensity. The infiltration capacity $Q_{V,M}$ is determined using equation 4.35 as the product of the infiltration-effective surface A_s and the hydraulic conductivity $k_{f,M}$ of the swale bed.

With reference to ATV A138 (ATV 1990) the following equation is obtained:

$$V_M = \left(\Sigma Q_{z,M} - Q_{V,M}\right) \bullet T \bullet 60$$
$$= \left(A_{red} + A_s\right) \bullet 10^{-7} \bullet r_T(n) \bullet T \bullet 60 - A_s \bullet \frac{k_{f,M}}{2} \bullet T \bullet 60 \quad (5.2)$$

where V_M = swale storage volume (m³) A_{red} = area of connected discharge-effective surfaces (m²)

A_S = area of available infiltration surface (m²)

$k_{f,M}$ = hydraulic conductivity of the swale bed (m/s)

r_T (n) = standard rain loading (l / (s * ha)) according to ATV A118

T = duration of dimensioning rain (min)

The available or necessary infiltration surface A_S is not usually known at the point in time of pre-dimensioning. Hence, the parameter A_S / A_{red} is selected as entry for the pre-dimensioning. The default value for A_S / A_{red} in STORM© is 0.1. The actual A_S / A_{red} relation is calculated after pre-dimensioning.

The rain load in equation 5.2 is calculated according to A 118 as follows:

$$r_T(n) = r_{15,(1)} \bullet \frac{38}{T+9} \bullet \left(\frac{1}{\sqrt[4]{n}} - 0{,}369\right) \quad (5.3)$$

where $r_{15,(1)}$ = rain loading according to Reinhold (l / (s * ha))

n = frequency level of the dimensioning rain / overflow frequency of the swale (1/ a)

The duration of the dimensioning rain T_M for the swale is then calculated as follows:

$$T_M = \sqrt{\frac{(A_{red} + A_s) \bullet \left(\frac{1}{\sqrt[4]{n}} \bullet 0{,}369\right) \bullet r_{15,(1)} \bullet 3{,}42 \bullet 10^{-5}}{A_s \bullet k_{f,M}/2}} - 9 \quad (5.4)$$

By inserting the values from equation 5.2 and 5.3 into equation 5.4, the necessary swale volume is determined. This volume serves as a basis for the simulation in STORM©.

With the known swale volume and pre-selected swale dimensions (depth, embankment slope, length, width), the programme automatically calculates the infiltration-effective surface A_s of the trough using Equation 4.34 (for obelisk shapes).

3.2.1.4 Trenches

As for swale infiltration, pre-dimensioning of the trenches in STORM© also maintains continuity conditions and is based on the A 138 ATV (1990) guidelines.

An example calculation for the trench pre-dimensioning is represented in Figure 5.1.

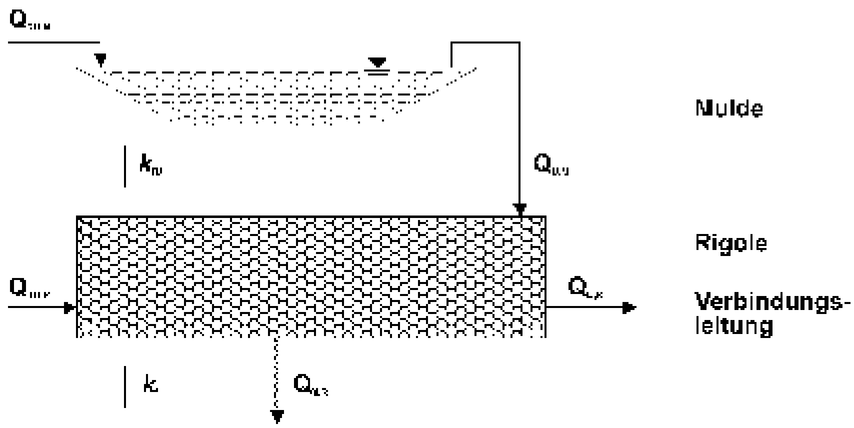


Figure 5-1: Flow scheme for pre-dimensioning trenches

The swale (or the swales which are attached to the trench) is completely filled and the overflow $Q_{Ü,M}$ is activated, i.e. $Q_{Ü,M} = Q_{Z,M}$. The storage effect of the swale attached to the trench is neglected and the inflows to the swale go directly into the trench (see also Section 5.1.3).

An additional inflow to the trench is $Q_{zu,R}$ which takes the throttle discharge of the upstream lying trenches into consideration.

The discharges $Q_{D,R}$ and $Q_{V,R}$ (according to Figure 6.1) are calculated in accordance to Section 5.4.4. The present network structure of the TRINT system is thus considered with respect to the throttle discharges of the trenches. This deviates from the A 138 (ATV 1990) guideline, which treats only decentralised structures/trenches. If the throttle discharge $Q_{D,R}$ is set to zero (directly in the trench input or by the regional throttle q_D in the menu option "Defaults"), then trench dimensioning is in accordance with ATV A138.

From the continuity condition the storage volume of the trench becomes:

$$V_M = \left(\Sigma Q_{zu,R} - \Sigma Q_{ab,R}\right) \bullet T \bullet 60$$
$$= \left[Q_{zu,R} + A_{red} \bullet r_T(n) \bullet 10^{-7} - Q_{D,R} - \left(b_R + \frac{h_R}{2}\right) \bullet l_R \bullet \frac{k_f}{2}\right] \bullet T \bullet 60 \quad (5.5)$$

V_R is determined from general geometrical relationships:

$$V_R = b_R \bullet h_R \bullet l_R \bullet \hat{s} \quad (5.6)$$

where V_R = trench storage volume (m³) b_R = trench width (m)
h_R = trench height (m)
l_R = trench length (m)
$\hat{s}$ = replacement storage coefficient (-) (Equation 4.39)

Equating equations 5.5 and 5.6 and solving for trench length l_R yields:

$$l_R = \frac{60 \bullet T \bullet A + \dfrac{T}{T+9} \bullet B}{b_R \bullet h_R \bullet \hat{s} + 60 \bullet T \bullet (b_R + h_R/2) \bullet k_f/2} \quad (5.7)$$

where $A = \left(Q_{zu,R} - Q_{D,R}\right)$ and $B = A_{red} \bullet 10^{-7} \bullet 38 \bullet \left(\frac{1}{\sqrt[4]{n}} - 0{,}369\right) \bullet r_{15,(1)}$

The duration of the design storm T_R for trench dimensioning results from the condition $\mathrm{d}l_R/\mathrm{d}T = 0$.

Determining of the maximum value from $\mathrm{d}l_R/\mathrm{d}T = 0$ leads to a set of quadratic equations, whose solution is found from:

$$T_R = -0,5 \bullet \frac{C2}{C1} + \sqrt{\left(\frac{C2}{C1}\right)^2 \bullet 0,25 - \frac{C3}{C1}} \quad (5.8)$$

where

$$C1 = 60 \bullet A \bullet b_R \bullet h_R \bullet \hat{s} - 60^2 \bullet B \bullet \left(b_R + \frac{h_R}{2}\right) \bullet \frac{k_f}{2}$$

$$C2 = 18 \bullet 60 \bullet A \bullet b_R \bullet h_R \bullet \hat{s}$$

$$C3 = 81 \bullet 60 \bullet A \bullet b_R \bullet h_R \bullet \hat{s} + 9 \bullet B \bullet h_R \bullet \hat{s} \bullet 60 \bullet b_R$$

If T_R is known, the storage volume of the trench, which is an input value for the simulation with STORM©, can be determined using Equations 5.7 and 5.6.

3.2.1.5 Stormwater Retention Tanks

Pre-dimensioning stormwater retention tanks occurs in STORM© according to the German guidelines ATV A117 (1977[2]).
The required retention tank volume is determined from the difference between precipitation volume and discharge volume. The precipitation volume is equated with the swale inflow Qz,RRB and calculated with the runoff-effective surface and a locally specific rain intensity.
$Q_Z = r_{T(n)} \bullet A_{red}$ (5.9) where Qz = inflow to the retention tank (m³/s)
Ared = connected runoff-effective surface (m²) rT (n) = actual rain intensity (l/(s·ha)) The discharge capacity QD,RRB is determined from the throttle capacity of the tank: $Q_{ab} = \frac{1}{2}(Q_{ab\min} + Q_{ab\max})$ (5.10) where Qab = discharge from the retention tank (m³/s)
Qab,min = min. throttle discharge at h=0 (m³/s) Qab,max = max. throttle discharge (m³/s) From this follows the discharge ratio:
$\eta = \frac{Q_{ab}}{Q_{r15}} = \frac{Q_{ab}}{r_{15(n)} \bullet A_{red}}$ (5.11) where h = discharge ratio (-)
Qr15 = discharge from the retention tank (m³/s) r15(n) = 15-minute rain intensity of frequency n (l/(s ha)) The rain intensity is calculated so:
$r_n = r_{15(n)} \bullet \varphi_m = r_{15(n)} \bullet \frac{24}{T_m + 9}$ (5.12) where rn = rain intensity of frequency n (l/(s ha))
jm = coefficient
Tm = precipitation duration (min) and
$T_m = 24 \bullet \sqrt{\frac{9}{24\,\eta - t_f\,\eta^2}} - 9$ (5.13) where tf = flowtime in the sewer to the retention tank (min)
The rated value for stormwater retention tanks BR (in s) is calculated so:
$BR = \left[T_m \cdot \varphi_m - \eta \cdot (T_m + t_f) \cdot \frac{\eta^2 \cdot t_f}{\varphi_m}\right] \cdot 60$ (5.14) According to German standards in ATV A117, the required tank volume is calculated so: $V_{RRB} = \frac{BR \cdot Q_{r15}}{1000}$ (5.15) where VRRB = required tank volume (m³)

Locating several stormwater retention tanks one after another cannot be considered according to A117 in STORM© during pre-dimensioning, but certainly can be during long-term simulation. It should be kept in mind, however, that the runoff concentration process is not set up as a technical model, and therefore large, conventionally drained catchments cannot be mapped out.

3.2.2 Process Simulation

Once a system file (*.mrs) is complete, such as all pre-dimensioned storage volume data for troughs and trenches, a long-term simulation can be carried out with STORMİ.

The storage elements are calculated in STORMİ by successive time-steps and elements taking the network of the system elements into consideration.

First, the programme STORMİ reads the available rain data, which must be in MD – format (see section 4.1), whose time step discretization t_N must correspond to that of the simulation t. The calculation period and the available precipitation files are defined in the parameter file (*.mrp). If the existing precipitation depth does not equal zero, the calculation of the precipitation phase begins. With a precipitation depth of zero, the processes of the drying phase are simulated.

The precipitation phase begins with the calculation of the discharge-effective precipitation by means of the available precipitation depths N. Wetting losses and swale losseslosses are calculated, in accordance to specifications, for different surface types connected to the respective element (always a swale) (see section 4.3).

Hence, the wetting and the degree of swale filling from the previous calculation interval are considered. The beginning of an event is defined in such a way that it coincides with the first discharge of the connected surfaces. The discharge results from the product of the connected surface area and the effective precipitation depths.

The calculation continues with the simulation of the storage processes. Inflows and discharges are balanced at the storage element according to Section 4.5.12 taking the evapotranspiration (optional with swales) and the translation effects (from discharges of upstream lying trenches) into consideration. The water flows which are balanced are depicted in Figure 5-2 for two swale-trench units. If a further storage element exists in the downstream direction or as an independent strand (in Figure 5-2, trench 2), the calculation is continued within the time interval h_N and with the precipitation depth for the new storage element.

If all storage elements are treated within one time interval, the simulation begins with the next time interval, or the calculation is terminated with the creation of an output listing (including the pertinent statistical analysis).

The simulation of a drying phase time steps and elements occurs as follows:

- the reduction of wetting and the filling of swales on the connected surfaces by evaporation.
- the evaporation from the swale (Q_E^{M1}) and swale bed (only for emptied swales, e.g. Q_E^{B2} in Figure 5-2) storage elements.

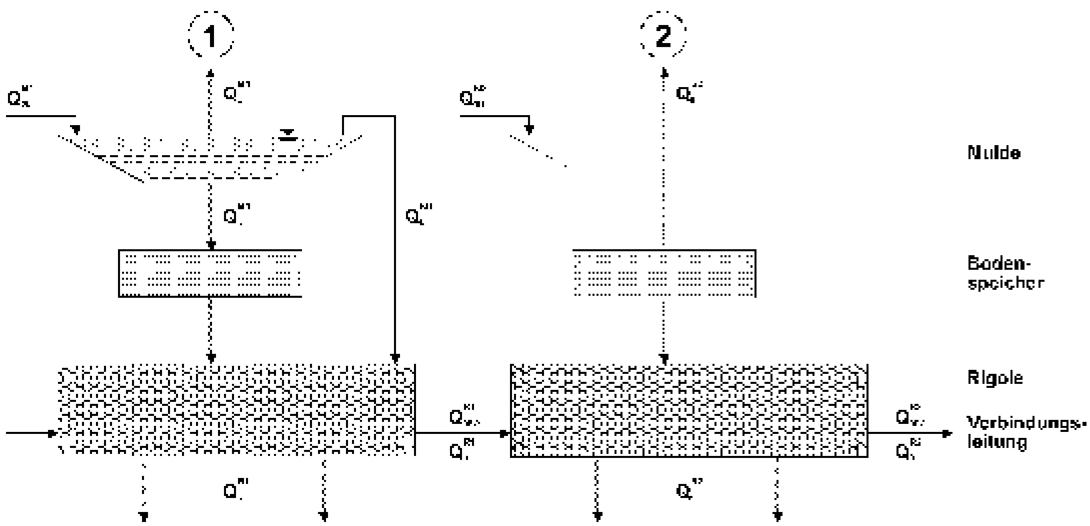


Figure 5-2: Flow scheme for storage simulation shown using two swale-trench units

If the storage elements are still filled with water, the storage simulation is continued by the balancing of inflows and discharges (without inflow from precipitation) one element at a time within the time interval. If a storage element is empty, the precipitation event for that element is terminated. If the element happens to be a swale, then the evaporation from the swale bed (ground storage) can begin.

After all storage elements of the swale-trench system have been treated in the drying or precipitation phase, the simulation begins for a further time interval - with a drying or a precipitation phase - or the simulation is terminated.

3.2.3 Statistical Analysis

With the STORM© simulation the storage elements, the discharges and, if required, the overflow of each storage element are calculated. For each impounding event, maximum values of the following are stored in memory:

- inflow hydrograph (l/s)
- overflow hydrograph (l/s)
- impounding volume (m^3)
- total water stoppage (m^3)

From the summation values of the impounding and overflow volumes a partial series is determined and viewed as a single sample of the whole.

For the theoretical frequency predictions, the return time of the individual values ("events") of the partial series are estimated with the following plotting formula:

$$T = \frac{L + 0,2}{k - 0,4} \bullet \frac{M}{L} \quad (5.16)$$

where L = number of single sampling values (-) T = return time (a)
M = number of years of rain data file (-)
k = order number of single values, where k = 1 corresponds to
the large value and $k = L$ to the small value

Thus, for example, for the largest of 58 values out of 21 years, the theoretical return time is approximately 35 years, for the second largest approximately 13 years, and for the third largest approximately 8 years, etc.

The number of single sample values, which are determined element for element (for each swale and each trench), can be selected globally in STORM© (which determines the range of the output). The sample size can be selected by, for example, L » 2.7 · M.

This estimation of the return times, which is larger than that resulting from a more fundamental frequency view point ($T_n = M/k$), represents a more extreme value of the calculation. With this is taken into consideration, that a less frequent event can occur in a sample of a certain time series.

The given plotting formula for the estimation of the return time is based on the assumption that the calculated values are exponentially distributed.

Theoretically, the specification of other distributions would have also been possible, however, just as arbitrarily chosen as the one selected, since one cannot determine which distribution function best fits the whole system. Hence, a comparison of different distribution functions and their effect on the results can be neglected.

A linear function of the sample values can be obtained if they are plotted as a function of the logarithmic estimated return time. Such a linearity allows the parameter representing the exponential distribution to be determined by simple linear regression. The existence of such a balancing function cannot always be presupposed. In many cases it will therefore be more meaningful if the calculated values are interconnect or fitted with a balancing function graphically.

The aforementioned data of the events are sorted according to their size and given as output according to the specified return frequency calculation $n = 1/T$ (1/a).

In a summary of the simulation results the results and sizing specifications of the pre-dimensioning are printed in juxtaposition with the calculated results of the corresponding return frequency.

The output listing for swales may additionally include the calculated return frequencies sorted by the impounding duration.

3.2.4 Schmutzfrachtberechnung

Neben den Wassermengen können in STORM© auch Schmutzfrachten berechnet werden. Hierzu können bis zu sechs Schmutzparameter definiert werden. Die Berechnung der Schmutzfrachten erfolgt nach der Komponenten-Methode. Dabei überlagern sich die Frachtkomponenten der einzelnen Teilströme

- Trockenwetterfracht und
- Regenwasserfracht

3.2.4.1 Polluting Load Formation

During polluting load formation, as with runoff formation, the amount of pollution that makes its way into the sewer system is calculated. The combined sewage discharge is composed of two components- stormwater and dry weather discharge.

3.2.4.1.1 Pollution of Stormwater Runoff

Stormwater runoff is a discontinuous process that is dependent on the precipitation characteristics in a catchment.
The stormwater concentration is assumed to be a constant over the entire stormwater runoff period. This is multiplied by the current stormwater runoff to determine the pollution load.
$h_{Ne,i} = h_N - h_{m,i}$ (5.17)
where CR = stormwater concentration
qR,t = stormwater runoff
fR,t = stormwater concentration
STORMİ offers the possibility to compute with

- constant stormwater concentrations over the entire simulation period or with
- average yearly pollution degradation.

Computing with contant stormwater concentrations with different precipitation amounts leads to a different pollution load yield on the surface. Also, an increasing pollution load yield is simulated with increasing runoff-effective precipitation.
When computing with average yearly pollution degradation, the concentration average values are calculated from the yearly area-specific runoff-effective precipitation.
The per year substance potential that can be washed out by rainwater is divided by the local yearly runoff volume per hectare of sealed surface (runoff-effective precipitation 1mm/a = 10 m3/(hared*a)). This yields a locally specific, average yearly concentration of a particular substance in the stormwater runoff. For example, the average yearly stormwater runoff concentration 10 mg/l with a substance potential of 50 kg/(hared*a) and a runoff-effective precipitation ratio of 500 mm/a amounts to 5.000 m3/(hared*a). If, in another catchment, 700 mm/a becomes runoff-effective, the average stormwater runoff concentration amounts to 7.14 mg/1 (with the same substance potential of 50 kg/(hared*a)).
In contrast to the approach of overall the same yearly average values for the stormwater runoff concentration, it must be taken into account when establishing an average yearly potential that in catchments with high amounts of precipitation, the stormwater runoff and therefore the mixed

sewage discharge is less polluted (more dilluted) than in a similar catchment with less precipitation, where, because of weaker dillution, the stormwater runoff is more polluted.

The internal computation of the average substance concentrations from the substance potentials requires knowing the surface-specific, runoff-effective precipitation. For this, a pre-run is carried out before the actual simulation. Here, the runoff-effective precipitation is calculated so that the yearly stormwater concentration can be used in the calculations at the start of the simulation.

3.2.4.1.2 Dry Weather Runoff Pollution

For dry weather runoff pollution, essentially the same pollution load hydrographs can be indicated as for larger runoff amounts. This, however, leads to constant dry weather concentrations. Measurements from treatment plant inflows indicate, nevertheless, that the dry weather concentration appears like a daily hydrograph.
In order to accont for this daily hydrograph in STORMİ, user-defined load hydrographs can be input. Alternatively, default hydrographs can be used. These hydrograhps are based on load hydrographs recommended by Imhoff.

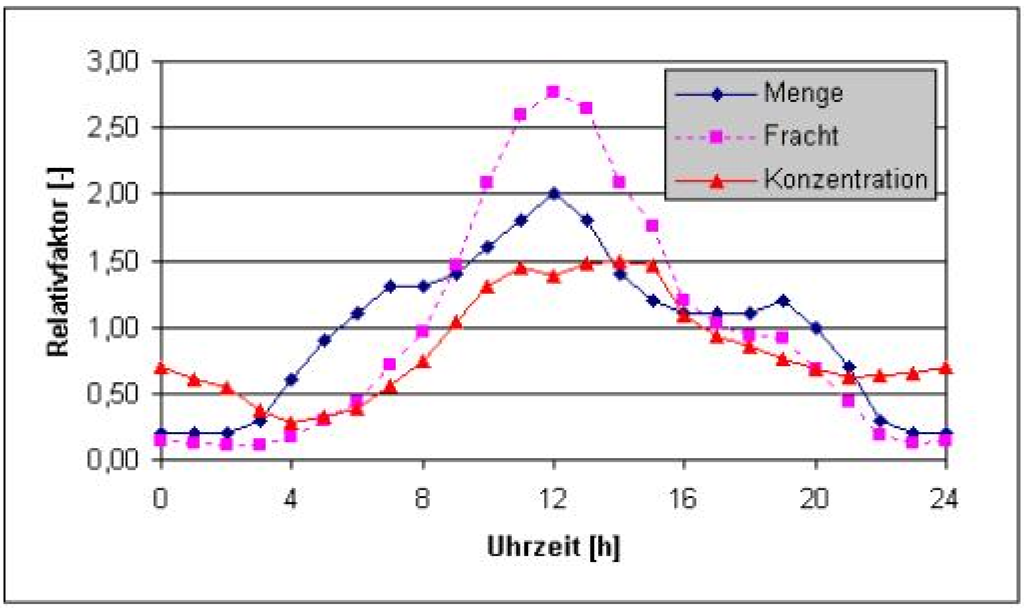


Figure 5-3: Relative factors for average runoff and pollution load hydrographs for 10,000 - 50,000 inhabitants with the concentration hydrograph derived from it

3.2.4.2 Computing Pollution Load Hydrographs

Like with the runoff concentration process, the temporal division of washed out pollution is determined at the low point of the concentration catchment during the pollution concentration process. Even here, a time-invariant, superpositionable transfer function is used.

It is assumed that the washed-away pollution load is not considerably altered between the location of pollution formation and the point of concentration. Sedimentation or erosion phenomena that go beyond the pollution formation are not taken into account. Sedimentations- oder Erosionsphänomene, die über die Schmutzbildung hin- ausgehen, werden nicht berücksichtigt. If this idealisation is required, pollution concentration computations can be carried out similarly to runoff concentration calculations. The transfer function has the same properties and can be calculated with the same methods.

The system runoff is extended by an indication of the composition of the precipitation. The system response is a pollution load function.

The following applies to a storage cascade for depicting the loading rate:

$$f_t = \sum_{i=1}^{n} \binom{n}{i} \bullet (-1)^{i-1} \bullet \alpha^i \bullet f_{t-i} + A_E \bullet \frac{(1-\alpha)^n}{2^{n-1}} \bullet \sum_{i=0}^{n-1} \binom{n-1}{i} \bullet N_{W,t} \bullet C_R$$

(5.18) where n = number of storages

K = storage constant

?t = timestep

NW,t = current runoff-effective precipitation intensity ft = loading rate

AE = catchment surface area CR = stormwater concentration a = e-?t / K

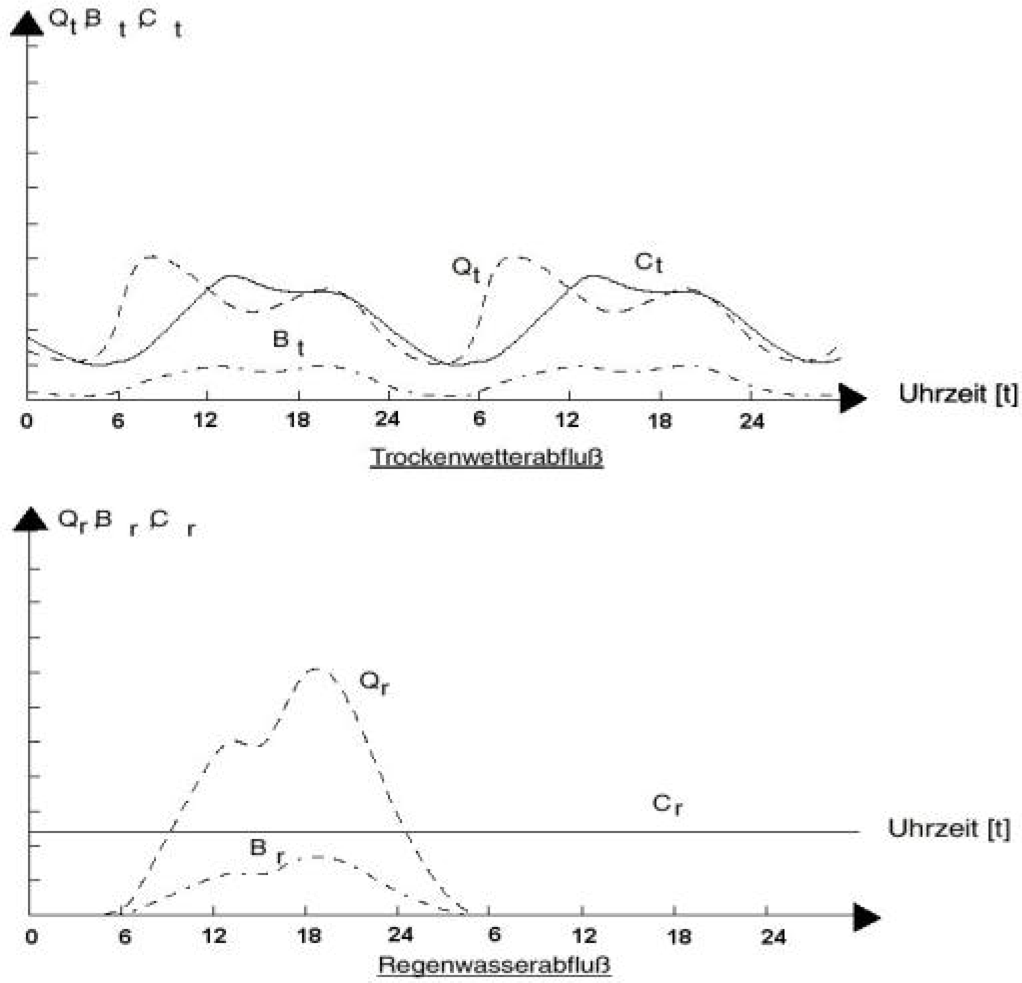
For constant stormwater concentrations, equation 5.18 can be considerably simplified. A distortion of the runoff amounts of water takes place in the storage cascade. The pollution of the stormwater is constant. Corresponding to this, the pollution of the stormwater currently running off is also constant.

$C_{R,ab} = C_{R,zu}$ (5.19) To simplify the calculation, the stormwater concentration can be multiplied by the discharge from the storage cascade instead of using equation 5.18. One will arrive at the same value.

$f_t = C_R \bullet q_t$ (5.20) Equation 5.20 is implemented in STORM©.

3.2.4.3 Pollution Superposition

The stormwater loads are overlayed chronologically synchronously with the daily cycle of the pollution loads. Along with it emerge variable combined sewage concentrations that are determined from the portions of pollution loads and runoff of the separate components. The superimposition process is portrayed in figure 5-4.



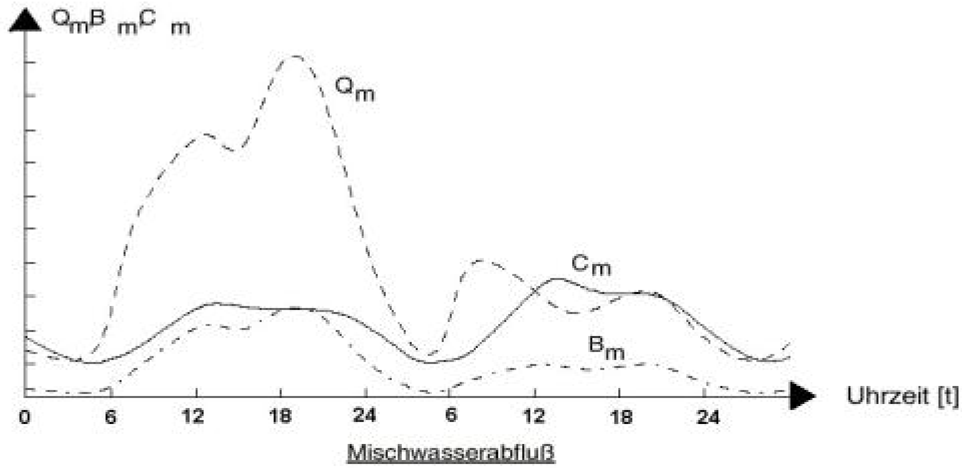


Figure 5-4: Superimposition process according to the components method According to the components method, the stormwater concentrations are calculated separately for each particular surface. The stormwater runoff from the surfaces is multiplied by the selected constant concentrations.

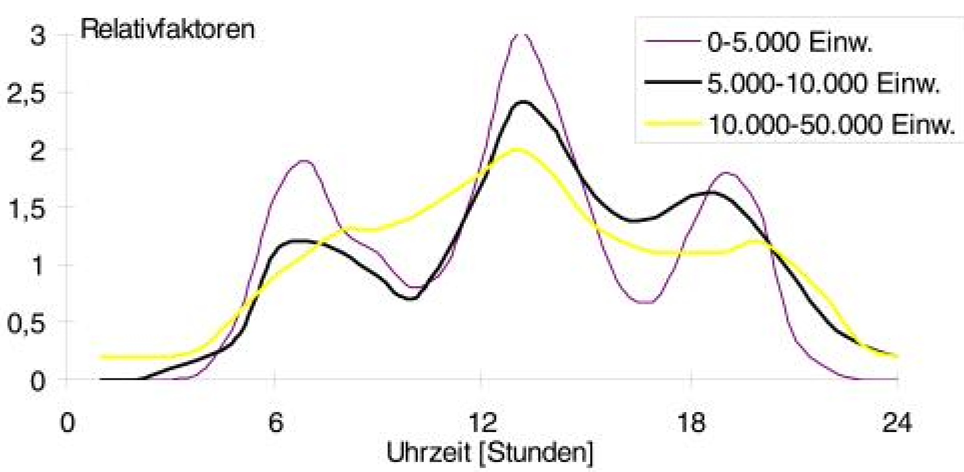


Figure 5-5: Polluted water hydrograph according to ATV, Part 1

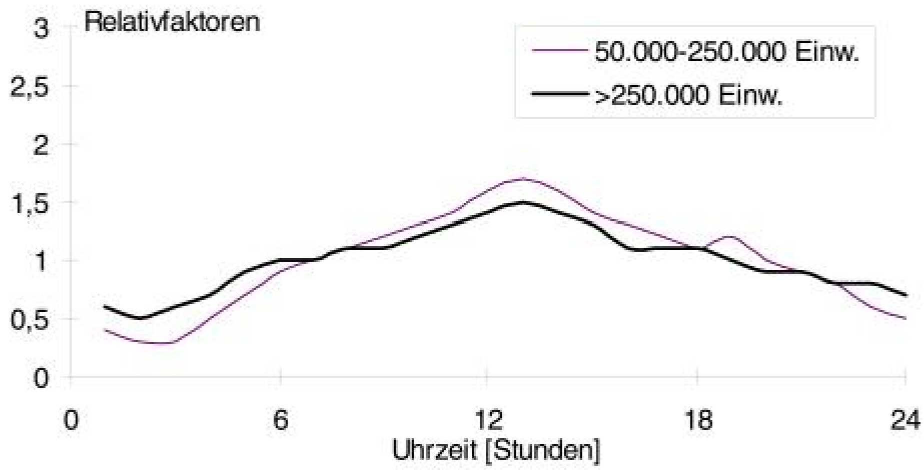


Figure 5-6: Polluted water hydrograph according to ATV, Part 2

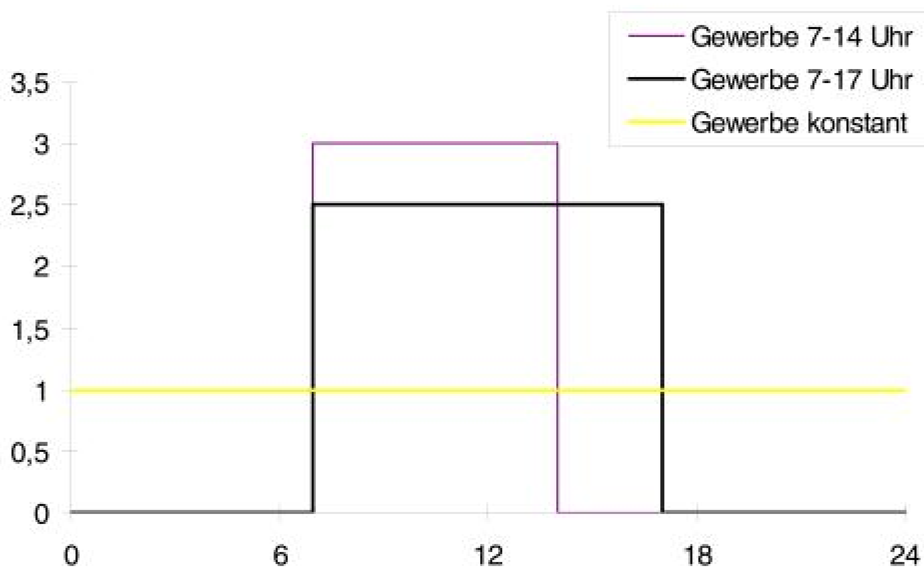


Figure 5-7: Polluted water hydrograph for industrial operations

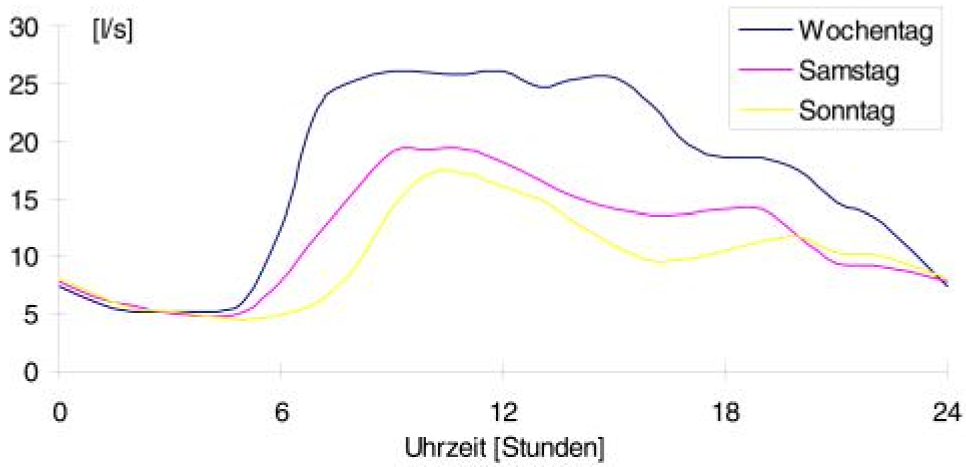


Figure 5-8: Polluted water hydrograph for different days (sample)

The combined sewage concentration Cm,t is calculated as follows:

$$C_{m,t} = \frac{Q_{TW,t} \bullet C_{TW,t} + \sum_{i=1}^{n} Q_{R,t} \bullet C_R}{Q_{TW,t} + \sum_{i=1}^{n} Q_{R,t}} \qquad (5.21)$$

where t = timestep (5 minutes)

QTW,t = dry weather runoff in l/s QR,t = stormwater runoff in l/s CTW,t = dry weather concentration in mg/l CR = stormwater concentration in mg/l (constant) n = number of connected surfaces From the superimposition with the runoff hydrograph, one obtains a combined sewage pollution load hydrograph.

3.2.4.4 Pollution Transport

At each inflow point at which a sewer-connected surface or a single inlet flows into the transport collector, a chronologically synchronous superimposition of stormwater and dry weather runoff and the substances contained within it take place.
A chronologically variable mixed concentration of the combined sewage discharge is calculated using a mixed calculation under the assumption of complete mixing of both portions of runoff that appear in each particular timestep. A conservative substance behaviour is assumed; that is, during the course of transport, no substance substitution takes place.

3.2.4.4.1 Computation with Translation

As with the runoff transport calculation, the loads are pushed along through the transport course like a cork or stopper without changing the shape of the hydrograph. The flowtime ft is already known from the runoff transport calculation.

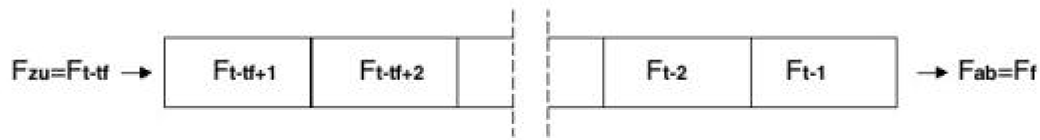


Figure 5-9: Translation of pollution loads

3.2.4.4.2 Pollution Transport with Retention and Translation

The Kalinin-Miljukov Process can be applied from the runoff transport directly to pollution transport. The runoff component must be extended here simply by one pollution component.

$$f_{ab,t} = \sum_{i=1}^{n} \left(\frac{n}{i}\right) \bullet (-1)^{i-1} \bullet \alpha^{i} \bullet f_{ab,t,-i} + \frac{(1-\alpha)^{n}}{2^{n-1}} \bullet \sum_{i=0}^{n-1} \left(\frac{n-1}{i}\right) \bullet f_{zu,t} \quad (5.22)$$

where fab,t = loading rate at the end of the transport course at time t fzu,t = loading rate at the beginning of the transport course at time t a = e -?t / K

?t = timestep

K = storage constant

n = number of storage

$\left(\frac{n}{i}\right)$ = binomial coefficient

3.2.4.5 Substance Distribution in Combined Sewage Facilities

Runoff and substance distribution takes place in discharge facilities. Depending on the type of facility, the combined sewage is treated differently. The German guidlines ATV A 128 classifies the discharge facilities according to their function into the following types of facilities:

- stormwater overflow (RUE)
- throughflow tank (online) (DBH)
- throughflow tank (by-pass) (DBN)
- retention tank (online) (FBH)
- retention tank (by-pass) (FBN)
- sewer with storage capacity, underlying discharge (SKUE)
- sewer with storage capacity, upstream discharge (SKOE)

The storage of combined sewage and the sedimentation of settling substances is a part of combined sewage treatment. The storage is required due to the limited sewer and treatment plant capacity. The throttled discharge from combined sewage tanks is generally limited to the maximum treatment plant intake 2*Qs+Qf.

For a simple overflow, the entire excess amount of water, the difference between inflow and discharge, is disregarded.

In order to be able to calculate the performance of discharge facilities, storage spaces are loaded in the calculation with the simulated discharge and pollution load hydrographs for partial catchments. The filling, storage and emptying processes for the tanks are simulated continuously.

Sewer storage spaces with underlying release are treated in the computation like on-line throughflow tanks and sewer storages with upstream release are treated like retention tanks because the corresponding filling and storage processes are identical.

In the following system sketch and computation equations, the abbreviations have the following meanings: *Discharges* in m3/s: Qzu: Inflow to a discharge facility Q*zu: Inflow to the tank Qab: Discharge to a treatment plant Q*ab: Emptying a by-pass tank Qkue: Treated overflow Qbue: Tank overflow *Volume* in m3: VB: Stored volume in the tank

Concentrations

in mg/l or ml/l: Czu: Inflow concentration Cab: Concentration of the discharge to the treatment plant Ckue: Concentration of the treated overflow Cbue: Concentration of the tank overflow CB: Concentration in the tank Cü: Overflow concentration = f(CKü,CBü)

3.2.4.5.1 Stormwater Overflow

With a simple overflow, the arriving discharge and pollution loads are split up. Water storage does not take place.

The overflow concentration is the same as the inflow and discharge concentration.

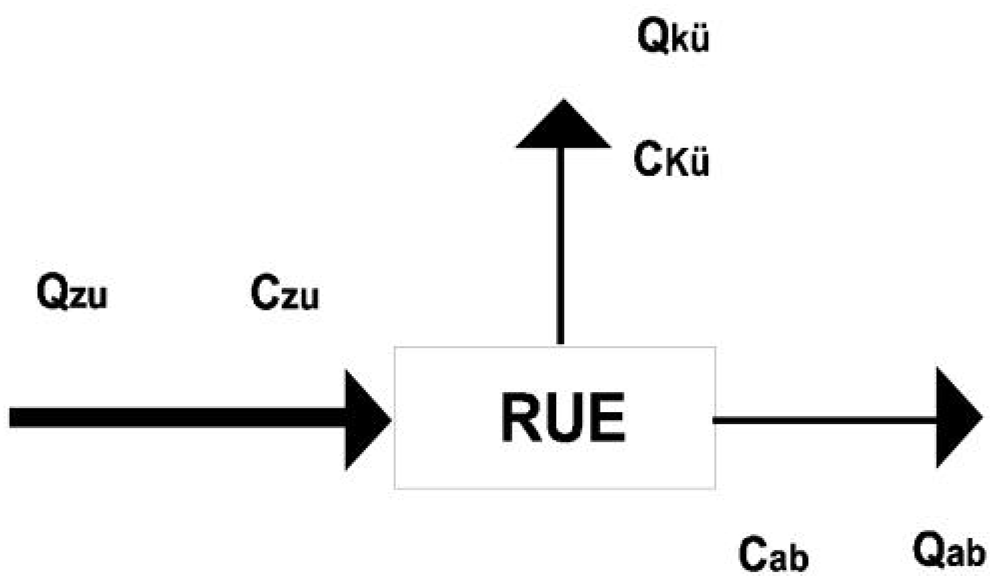


Figure 5-10: Stormwater overflow

3.2.4.5.2 Throughflow Tanks

Throughflow tanks (on-line) (Figure 5-9) store the arriving waters that are not discharged by the throttle. When the tank is full, the treated overflow on the downstream end of the throughflow tank switches on. The overflow load is reduced as a result of the pollution load sedimentation. This process can be most closely observed with sediment substances.
If the tank inflow is larger than the sum of the tank discharge and the treated overflow, the tank overflow, which is located at the inlet to the discharge facility, switches on. Here, the unsettled combined sewage is diverted directly to the receiving waters.

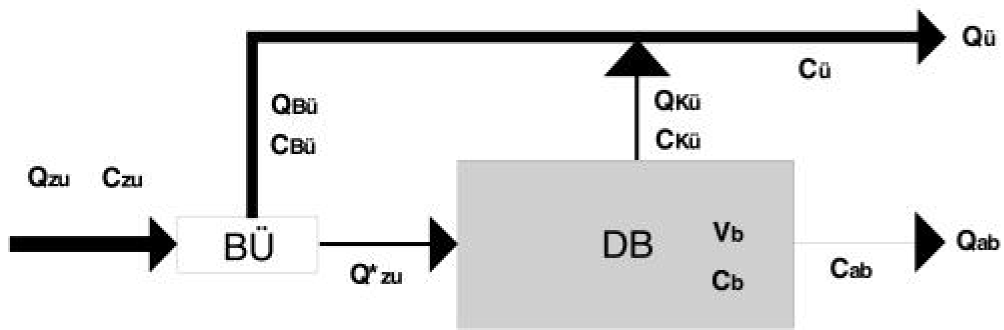


Figure 5-11: Throughflow tank (on-line)

In contrast to on-line throughflow tanks, where dry weather runoff is led directly through the tank, dry weather runoff detours the discharge facility with by-pass throughflow tanks.
The advantages to the by-pass tank include the small hydraulic impact on the tank as well as the retention of pollution loads at the end of the rain event. At that time, the sewage supply is cut off and has no further effect on the tank concentration.

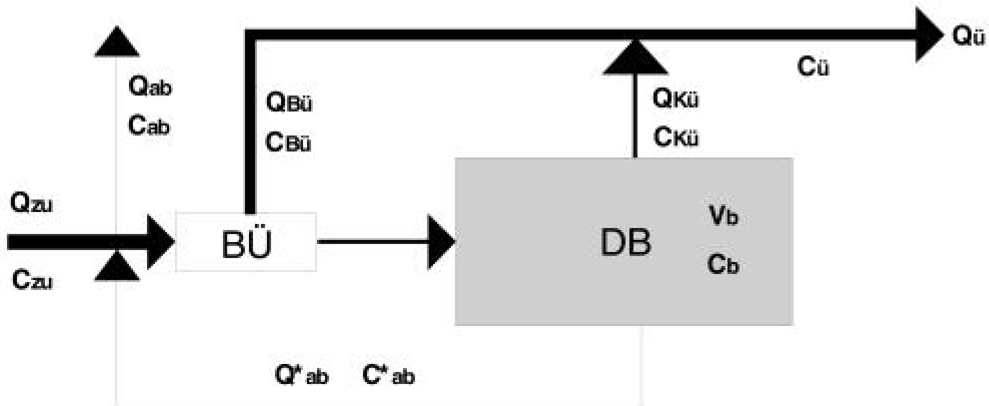


Figure 5-12: Throughflow tank (by-pass)

3.2.4.5.3 Retention Tanks

In contrast to throughflow tanks, retention tanks don't have a treated overflow. In order to avoid releasing initial flush, the runoff is stored at the beginning of the runoff event and, with on-line retention tanks (Figure 5-11), throttled further. With by-pass retention tanks, emptying the tank only occurs at the end of the rain event.
The tank overflow only turns on when the tank is completely full.

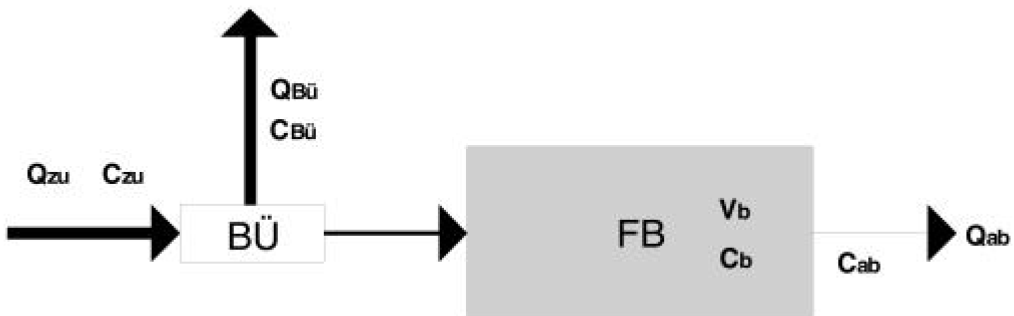


Figure 5-13: Retention tank (on-line)

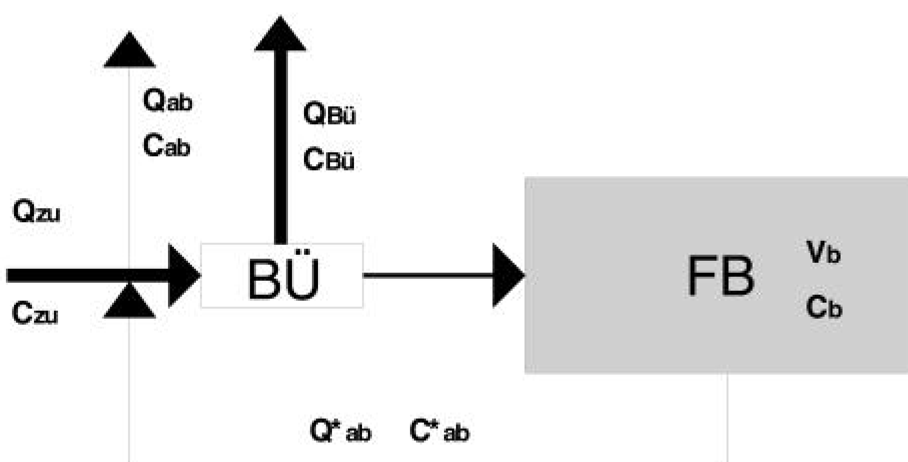


Figure 5-14: Retention tank (by-pass)

3.2.4.5.4 Concentration Computation

Regardless of the type of tank, the polluting load concentration in the tank is calculated under the assumption of complete mixing with the following equation:

$$C_{B,t} = \frac{V_{B,t-1} \bullet C_{B,t-1} + Q^*_{zu,t} \bullet C_{zu,t} \bullet \Delta t}{V_{B,t-1} + Q^*_{zu,t} \bullet \Delta t} \quad (5.23)$$

The volume already located in the tank at the beginning of the considered time interval VB,t-1 is calculated from balancing the possible tank inflows and discharges, although some terms in the following equation (5.24) can be omitted depending on the type of tank or depending on filling, overflow or emptying phase because its value is zero or is not relevent for the type of tank under consideration.

$V_{B,t-1} = V_{B,t-1} + \Delta t \bullet \left(Q^*_{zu,t-1} - Q^*_{ab,t-1}\right) \geq 0$ (5.24) The inflow and discharge terms in equation 5.24 are determined for on-line tanks as follows:

$Q^*_{zu} = Q_{zu} - Q_{Bue}$ (5.25) $Q^*_{ab} = Q_{ab}$

and for by-pass tanks:

$Q^*_{zu} = Q_{zu} - Q_{ab} - Q_{Bue} \geq 0$ (5.26) $Q^*_{ab} = Q_{ab} - Q_{zu} \geq 0$

The concentrations of the discharges relevant to a load calculation assume the following values:

- the following applies regardless of type of tank: Cbue= Czu
- the following applies for throughflow tanks: Ckue = CB

The throttled discharges to the treatment plant with on-line tanks show the concentrations:

$C_{ab} = C_B$ when VB> 0 (5.27) $C_{ab} = C_{zu}$ when VB= 0

and for by-pass tanks:

$C_{ab} = C_{zu}$ when VB= 0 (5.28) $C_{ab} = \frac{Q_{zu} \bullet C_{zu} + Q^*_{ab} \bullet C_B}{C_{zu} + Q^*_{ab}}$ when VB> 0

3.2.4.5.5 Sedimentation Effect in Combined Sewage Facilities

When storing combined sewage discharges, because of low flow speeds, deposits on the tank floor, and therefore a sedimentation effect, can occur. This effect is associated with lowering the treated overflow concentration. Physically justified approaches (e.g. sedimentation velocity according to Stokes) are available, however because of a few unknowns about the individual process and the composition of the combined sewage discharge (e.g. particle size distribution of the combined sewage inflow), it is not possible to successfully simulate the sedimentation process with deterministic methods.
Instead of that, for the sedimentation effect, the percent reduction of the treated overflow concentration is realised according to German Guidelines A-128. At the same time, the following procedure is chosen in STORMİ for taking the sedimentation effect into account:

- The tank overflows located in front of the tank (retention/throughflow tanks) release with the mixed concentration of the inflow; this is generally not influenced by the tank's sedimentation effect set in computation. (Solely with very large tank impoundage and simultaneous small tank inflow can a backflow from the tank to the tank overflow occur. In this case, partially sedimented combined sewage is released.)
- A percent of the polluting load flowing into the tank in the time interval is "deposited" in a virtual sludge storage. The rest is completely mixed with the existing concentration in the tank. There is a new temporary mixed concentration. Discharges via the treated overflow exhibit this mixed concentration.
- For the portion of COD that can sediment in the sludge storage, the following values are recommended for the sedimentation effect as a function of constructive design and hydraulic stress:
- no sedimentation effect: 0 Prozent
- poor sedimentation effect: 5 Prozent
- fair sedimentation effect: 10 Prozent
- good sedimentation effect: 15 Prozent
- By-pass tanks exhibit an unrestricted sludge storage. On-line tanks exhibit a sludge storage whose maximum mass in kg equates to 30% of the storage content in cubic metres. This corresponds to a dry sludge

layer of 1-2 mm thickness. When the maximum filling of the sludge storage with on-line tanks is reached, the portion of pollution load still sedimenting directly causes a higher mixed concentration in the tank.

- Draining the tank after the end of the rain event initially occurs (regardless of tank type and configuration) with the mixed concentration of the tank. The sludge storage formed during the event remains untouched. When the tank is 75% emptied, a complete mixing in the tank is assumed; the sludge storage is dissolved. This leads to an abrupt increase in the concentration of the combined sewage located in the tank (25% of the tank volume), which corresponds to the concentration of the discharge until the tank is completely empty.
- Through the described simulation of the sedimentation effect, solely the chronological concentration distribution of the discharge to the treatment plant is affected with retention tanks or partially filled throughflow tanks.

3.2.4.6 Substance Distribution in Swale-Trench Elements

Swale-Trench Elements are generally dimensioned to overflow frequency. For this, a pollution load calculation is necessary.
When considering combined systems, e.g. when the overflow to a swale is connected to a mixed sewage system, taking the polluting load into account can still be useful. For dividing up the substance loads into the swale and trench storage elements, a completely mixed reactor is assumed.
For the sedimentation effect and substance breakdown in swale-trench elements, there are at the moment still many unknowns. The following conclusions can apply to a qualitative classification:

- Semi-natural stormwater management is often used only for lightly polluted surface. For taking this into account in STORMİ, a lesser yearly pollution yield or a lesser stormwater concentration should be used for such partial surfaces.
- In swales and trenches, a considerable sedimentation effect occurs through the high specific volume (usually more than 200 cbm/ha). Through the minor overflow amounts from swale-trench elements, a sedimentation effect can be assumed for practically all overflow amounts. In STORMİ, this sedimentation effect can not be taken into account at this time. There is, however, the possibility to directly account for the sedimentation effect when inputting the yearly pollution yield or the stormwater concentration.
- In the swale bed, a definite substance accumulation or substance decomposition can be assumed due to the active soil layer. In STORMİ, a flat rate of accumulation or decomposition of 50% is used for this. This value was selected especially in consideration of the chemical oxygen demand - COD, as an average value for typically polluted surfaces. For very polluted or for only slightly polluted surfaces and for other substance parameters, other applicable values, that cannot, however, be taken into account with STORMİ, apply.

3.2.4.7 Substance Distribution in Stormwater Retention Tanks

Stormwater retention tanks are generally dimensioned to overflow frequency. A calculation of the pollution load is required for this. In STORMİ, pollution loads that are led to the stormwater retention tank can be indicated. In the retention tank itself, no sedimentation effects or substance decomposition is taken into account. The tank is considered to be a completely mixed reactor.

4.1 Literature

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4.2 Equation Symbols

A	Surface area
A_{red}	Runoff-effective surface
$A_{s,M}$	Swale surface area
$A_{s,R}$	Infiltration-effective surface of the trench
C	Swale loss process coefficient
E_{pot}	Potential evapotranspiration
F	Evaporation factor
f	Reducing factor for evaporation
G	Gravitational acceleration
h_B	Swale bed thickness
h_b	Wetting losses
h_M	Swale depth
h_m	Swale losses
$Q_{Ü,R}$	Trench overflow
$Q_{V,B}$	Infiltration from the swale bed
$Q_{V,M}$	Infiltration from the swale
$Q_{V,R}$	Infiltration from the trench
$Q_{Z,M}$	Inflow to the swale
$Q_{Z,R}$	Inflow to the trench
q_D	Regional throttling
r_T	Rain intensity
s	Storage coefficient of the filler material
$\hat{s}$	Substitute storage coefficient
T	Duration of the design storm
t	Time
VB	Wetting storage volume

h_N	Portion of precipitation	V	**Volume**
h_{Ne}	Runoff-effective portion of precipitation	V_{swale}	Swale storage volume
h_R	Max. water level in the trench	VR	Trench storage volume
h_v	Evaporation	D h_N	Hight of precipitation
k_f	Permeability coefficient of the soil	D h_v	Hight of evaporation
$k_{f,M}$	Permeability coefficient of the swale bed	D t	Computational timestep
nFK	Effective field capacity	e m	Degree of swale filling
$Q_{D,R}$	Throttled discharge	n	Kinematic viscosity
$Q_{E,B}$	Evaporation from the swale bed	y	Runoff coefficient
$Q_{E,M}$	Evaporation from the swale	y o	Initial runoff coefficient
$Q_{Ü,M}$	Swale overflow	y e	Final runoff coefficient

4.3 Abbreviations

The following abbreviations are used in STORM© in the data table and in creating the report:

Abbreviation	Unit	Description
Ablauf	[m³]	Ablauf aus dem System
Ared	[m²]	versiegelte Fläche
Breite	[m]	Breite in m
BR-Wert	[s]	Bemessungswert für Rückhaltebecken
BS	[-]	Bodenspeicher
BS Ablauf	[m³]	Bodenspeicher Ablauf
BS Verd.	[m³]	Bodenspeicher Verdunstung
BS Zulauf	[m³]	Bodenspeicher Zulauf
Dauer	[min]	Einstaudauer
Deck.grad	[%]	Deckungsgrad
DN	[mm]	Durchmesser
Drosselabl.	[m³]	Drosselablauf
Einst.Tiefe	[m]	Überlaufhöhe
Einstau+QübVol	[m³]	Einstauvolumen plus Überlaufvolumen
Entnahme	[m³]	Entnahme
erf. Vol.	[m³]	erforderliches Volumen
FiEnd	[mm/min]	Endinfiltration
FiNull	[mm/min]	Anfangsinfiltration
Fläche	[m²]	Fläche
Flächenname	[-]	Flächenname
Fließzeit	[min]	Fließzeit
Gefälle	[%]	Längsgefälle der Leitung
GOK oben	[m]	Geländeoberkante oben

GOK unten	[m]	Geländeoberkante unten
Intervall	[min]	Berechnungsintervall
jährl. Verd.	[mm]	jährliche Verdunstung
KD	[1/d]	Regenerationskonstante
Kf-Wert	[m/s]	Kf-Wert des anstehenden Bodens
KLD auto	[j/n]	automatische Drosselkennlinie
KLS auto	[j/n]	automatische Sickerkennlinie
KLÜ auto	[j/n]	automatische Überlaufkennlinie
KLV auto	[j/n]	automatische Volumenkennlinie
KRueck	[1/d]	Rückgangskonstante
Kurzbez.	[-]	Kurzbezeichnung
Länge	[m]	Länge
Max. Asick	[m²]	maximale Sickerfläche
Max. Einst.Vol.	[m³]	maximales Einstauvolumen
Max. Einstau	[m]	maximale Einstauhöhe
Max. Qüb	[l/s]	maximaler Überlauf
Max. Qzu	[l/s]	maximaler Zulauf
Min. WST.	[m]	Mindestwasserstand
Name	[-]	Name des Systemelementes
NameZiel	[-]	Name des Entwässerungszieles
nBem.	[1/a]	Bemessungshäufigkeit
Nbrutto	[m³]	Bruttoniederschlag in m³
Nbrutto	[mm]	Bruttoniederschlag in mm
Neig.	[1:x]	Böschungsneigung (der Mulde)
NEinstau	[-]	berechnete Einstauhäufigkeit
nFK	[%]	nutzbare Feldkapazität
Nnetto	[mm]	berechneter Nettoniederschlag
Nr.	[-]	Nummer des Bemessungsereignisses
NStatistik	[-]	Anzahl statistisch ausgewerteter Ereignisse

NÜber	[-]	berechnete Überstauhäufigkeit
nVorh.	[1/a]	vorhandene Häufigkeit
Objektname	[-]	Objektname
Objekttyp	[-]	Objekttyp
PsiA	[-]	Anfangsabflussbeiwert
PsiE	[-]	Endabflussbeiwert
qDrosAuto	[j/n]	automatischer Drosselleistung
qDrossel	[l/(s ha)]	Gebietsdrossel
QDrossel	[l/s]	Drosselleistung
Qmax	[m/s]	maximale Abflussmenge
Qüb auto	[j/n]	automatische Überlaufmenge
r15,1	[l/(s ha)]	Bemessungsregen, 15 minütig, 1 jährig
Regenschreiber	[-]	Name des Regenschreibers bzw. der Wetterstation
RHB	[-]	Regenrückhaltebecken
RS	[-]	Name des Regenschreibers bzw. der Wetterstation
rT,n	[l/(s ha)]	Bemessungsregenspende (allgemein)
RWEntnahme	[m³]	Regenwasserentnahme
Sohlbreite	[m]	Sohlbreite
Sohle Drän	[m]	Rohrsohle Dränrohr
Sohle oben	[m]	Sohle oben
Sohle unten	[m]	Sohle unten
Sohlfläche	[m²]	Sohlfläche
Sohllänge	[m]	Sohllänge
Speich.Vol.	[m³]	Speichervolumen
Stationsname	[-]	Stationsname
Summe Qab	[m³]	Summe der Abflussmenge
Summe Qüb	[m³]	Summe der Überlaufmenge
Summe Qzu	[m³]	Summe der Zulaufmenge

tägl. Verd.	[mm]	tägliche potentielle Verdunstung
Tentl.	[h]	Entleerungsdauer
tf	[min]	rechnerische Fließzeit des Berechnungsregens im Kanalnetz (bis zum Rückhaltebecken)
Tiefe	[m]	Tiefe
Tmax.	[min]	maximale Einstaudauer
TVorh.	[min]	vorhandene Zeit
TWZugabe	[m³]	Trinkwasserzugabe
Überlauf	[m³]	Überlaufvolumen
Vben	[mm] / [m³]	Benetzungsverlusthöhe
Verdunst.	[m³]	Verdunstung
Verdunstung	[-]	Verdunstung
Versick.	[m³]	Versickerungsmenge
Vmuld	[mm] / [m³]	Muldenverlusthöhe
Volumen	[m³]	Volumen
vorh. Vol.	[m³]	vorhandenes Volumen
Wandst.	[mm]	Wandstärke
Zeit	[min]	Zeit
Ziel	[-]	Entwässerungsziel
Ziel Drossel	[-]	Ziel Drosselablauf
Ziel Überlauf	[-]	Ziel Überlauf
Ziel Versick.	[-]	Ziel Versickerung
Zulauf	[m³]	Zulauf

4.4 Glossary of Technical Terms

Runoff Coefficient

The runoff coefficient describes the relationship between runoff and precipitation intensity. Runoff coefficients are not constant, but rather variable with time and are a function of, for example, the amount of sealed surface, the surface slope and recent precipitation events.

Runoff Formation
The process of runoff formation describes the development of precipitation runoff on sealed or un-sealed surfaces. During this process, depending on the selected runoff formation method, various losses such as evaporation loss (evapotranspiration), infiltration, etc. are taken into account.

Runoff Formation Method
A technical modelling approach for calculating the runoff formation. Examples are the limit method or using a constant runoff coefficient.

Runoff Formation Parameter
For wetting and trough losses as well as discharge factors, standard parameters of the runoff formation are suggested by STORM©. These can be extended by the user’s own types of surfaces and changed in the dialog window "Runoff Formation Parameters Properties". Since impermeable and permeable surfaces have different calculation procedures, there are different runoff formation parameter elements for sealed and unsealed surfaces in STORM©. Before the surfaces are given as input to the calculation model, runoff formation parameter elements are to be created for each type of surface.

Discharge Throttling
Also called discharge retention. Stretches the discharge surge out over time through temporary storage. Discharge throttling can be attained with various storage elements in STORM©.

Runoff Concentration
The process of runoff concentration describes the delay and distortion of a discharge surge from its development on the surface until inflow into the drainage system.

Discharge Intensity
The discharge intensity is a value to be predefined in l/(s×ha) with which the (throttled) discharge is specified from the storage elements. Often regulatory specifications or water management constraints result in a permissable discharge intensity.

Initial Runoff Coefficient
The limit value method assumes that at the beginning of the swale filling phase certain surface portions are already runoff-effective. These surface portions are designated as initial runoff coefficients. The initial runoff coefficients for different types of surfaces suggested by STORM© are summarized in 4.1 on page 4–1.

Design Storm
A rain event with a certain statistical probability of occurring n (e.g. n=1/a), a certain duration (e.g. 15 min) and a locally specific rain intensity (in l/(s×ha)) or rainfall amount (in mm).

Wetting Loss
The wetting loss (mm) is an initial loss which is subtracted from the precipitation depth. Before runoff takes place, all surfaces must be moistened, i.e. the threshold value of the wetting losses must be exceeded. Depending on the type of surface, the wetting loss ranges between 0.1 and 2.0 mm. Values used for different types of surfaces in STORM© are summarised in table 4.1 on page 4-1.

Computation Timestep
Long-term simulation must be based on a constant timestep. In STORM©, the standard timestep is 5 min.

Soil Characteristic Values
In STORM©, the parameters for infiltration in swales and trenches as well as for the infiltration approach according to HORTON are entered using soil characteristic values.

Gross Precipitation
The precipitation that falls in an observable time period without taking losses (such as wetting loss) into account.

Continuous Loss
The difference 1 – ye (final runoff coefficient) represents permanent losses. Permanent losses are described by a final runoff coefficient that in turn can be interpreted as a proportion of runoff-effective surface to total surface.

Drainpipe
Drainpipes are laid in trenches in order to make drainage possible in a reasonable amount of time, even with soils of very low permeability. Linking drainpipes to several trenches (with solid-walled connecting pipes) creates a swale-trench system. The required data can be entered in the "Dimensions" tab in the "Trench Properties" dialog window.

Throttled Discharge
The throttle discharge is calculated from the product of the total runoff-effective area of all upstream lying surfaces connected to the trench and the regional throttling (in l/(s×ha)). The throttle discharge will normally be calculated automatically by STORM© berechnet; it can, however, be given directly for each trench in the "Throttle" tab in the dialog window "Trench Properties".

Throttle Characteristic Curve
The throttle characteristic curve for the trench describes the discharge behavior of a trench in an interconnected swale-trench system. The standard description of the discharge behavior is a characteristic curve which runs from zero to the maximum and then remains constant. The throttle

characteristic curve describes the throttle capacity in relation to the water level.

Throttle Capacity

The maximum throttle capacity (l/s) represents the maximum discharge from the trench or stormwater retention tank without overflow. The throttle capacity can be calculated automatically by STORM©. The maximum regional throttling is multiplied by the total of all upstream connected, discharge-effective surfaces of the system. The maximum throttle capacity is a value for pre-dimensioning of a trench. Additionally, the throttle capacity is required for the automatic definition of the overflow characteristic curve thereby influencing the selection of the drainage pipe diameter.

Permeability

The permeability of the soil, the soil underneath swales and permeable surfaces, influences the infiltration of stormwater runoff. A swale-infiltration-trench system is of particular value in areas where the soil permeability does not suffice for a complete infiltration of the stormwater runoff.

Permeability Coefficient

In STORM©, the permeability of a type of soil is specified by the permeability coefficient (also called Kf-value).

Impound Volume

During a precipitation phase, the storage elements can become impounded. The volume contained at a certain water level is designated as the impound volume. In STORM©, the impound volume, which is attained when the overflow hight is reached, is designated the max. impound volume.

Catchment Area

The sum of the surface area connected to a storage element.

Final Runoff Coefficient
During the trench filling phase the runoff-effective surface portion begins with the initial runoff coefficient and increases to the final runoff coefficient when all swale losses have been accounted for. In particular, the final runoff coefficient represents the relationship between runoff-effective surfaces and impermeable (sealed) surfaces. Final runoff coefficients for different types of surfaces suggested in STORM© are summarized in Table 4.1 on page 4–1.

Emptying Event
During analysis of the long-term simulation for cisterns, it is necessary to determine the number and duration of phases in which the cistern was empty and therefore had to be filled with drinking water.

Withdrawal Rate
A constant withdrawal rate (l/d) for the cistern, which is the daily amount of water removed for household use, can be defined in the "Usage" tab in the dialog window "Cistern Properties". The withdrawal rate depends, for example, on the rainwater demands of a household.

Replacement Storage Coefficient
Replacement storage coefficient is understood to be the relation of the storage volume including the storage in the drainage pipe to the total volume. With trench pipes, a replacement storage coefficient is formed in order to determine the effective storage volume. The replacement storage coefficient considers both the porosity of the trench filler material and the volume made available by the drainage pipe. The latter gains particular importance with trench pipes of considerable diameter.

Evapotranspiration
The entirety of soil evaporation, plant evaporation (transpiration) and interception.

Field Capacity

The effective field capacity nfK is the difference between the field capacity and the permanent withered/wilting point. The field capacity of the soil is understood to be the maximum quantity of water which can be held back in the soil against the force of gravity (gravitation potential). The permanent withered/wilting point (dead water) is the water, which is hygroscopically bound to soil particles with a high water surface tension which plants must overcome with capillary forces (turgescence). The effective field capacity is required to describe the storage capability of the ground storage between the swale and trench.

River/Stream

Serves as the receiving waters for the drainage system. In STORM©, runoff and discharges are balanced with the system element River/Stream. A (hydraulic or hydrodynamic) river/stream computation is not possible.

Full-step Approach

A technical modelling approach to storage calculation. In STORM©, a full-step approach is implemented for all storage elements.

Catchment

Several surfaces can be combined into catchments.

Catchment Drying

After the end of a precipitation event, the surfaces become dry again, including the spaces where wetting-loss water is stored (puddles, etc). The simulation of this process is of importance for long-term simulation.

Area Throttling

By specifying a constant discharge intensity for the various drainage elements, the discharges from a catchment can be throttled evenly.

Total Hight of Evaporation

See Evapotranspiration

Limit Value Method

The limit value method is a special runoff formation approach that is used in STORM© to calculate runoff from sealed surfaces (and in a derived form also for unsealed surfaces).

Green Roof
Green roofs make it possible to retain stormwater on roofs in densely built areas. They also contribute to an improved microclimate due to higher levels of evaporation.

Half-step Approach
An additional technical modelling approach to storage calculation. In STORM©, a half-step approach is implemented for all storage elements.

Horton
Der Infiltrationsansatz nach HORTON ist Bestandteil des Abflussbildungsansatzes für unbefestigte Flächen in STORM©.

Hydraulic Conductivity
The hydraulic conductivity (kf-value) or soil permeability (m/s) of the swale bed corresponds to the infiltration capacity of the soil when saturated (see also kf-value).

Infiltration Method
An infiltration method describes the infiltration of precipitaion on unsealed surfaces. In STORM©, the HORTON method is implemented.

Innodrain©
Similar to a swale-trench element, except that the embankment isn't made from soil material, but rather from a vertical concrete wall, thus requiring less surface area.

Interception
The portion of precipition that evaporates from the surface of the plants without even reaching the ground.

Yearly Variation
The exact calculation of the potential evaporation is very difficulty to obtain. To simplify the procedure the daily evaporation depths are averaged over many years and summarized as a mean yearly variation in Figure 4-2 on page 4–1.

Yearly Hight of Evaporation
The yearly potential total evaporation, reached over a multi-year average.

Kf-Value
The hydraulic conductivity can be determined from the particle size distribution. More meaningful, however, are the results from infiltration experiments.
Orders of magnitude for the *kf*-value are to be inferred from German guidlines in worksheet ATV A138:

- Coarse Gravel 5·10 -1 – 5·10 -3 (m/s)
- Fine/Medium Gravel 1·10 -2 – 5·10 -4 (m/s)
- Sandy Gravel 1·10 -2 – 1·10 -4 (m/s)
- Coarse Sand 5·10 -3 – 1·10 -4 (m/s)
- Medium Sand 1·10 -3 – 5·10 -5 (m/s)
- Fine Sand 5·10 -4 – 5·10 -6 (m/s)
- Sandy Loam 5·10 -5 – 5·10 -8 (m/s)
- Loam 5·10 -5 – 1·10 -9 (m/s)
- Clay-like Loam 5·10 -6 – 1·10 -10 (m/s)
- Loamy Clay 1·10 -8 – 1·10 -11 (m/s)

Continuum Simulation
The continuous simulation over usually longer time periods, including dry periods.

Long-term Simulation
Long-term illustration of the precipitation-runoff process in drainage systems.

Model Storm
An imaginary rain event that is used as a design storm. The simplest form of a model storm is the block rain. A complex model storm is, for example, the Euler-storm or critical load rain.

Swale
a) Infiltration swale for on-site stormwater management
b) smaller depressions on sealed or unsealed surfaces that contribute to losses during runoff formation.

Mulden-Rigolen-Element
Die Verbindung einer Versickerungsmulde mit einer darunter liegenden Rigole. Mulden-Rigolen-Elemente können einzeln oder vernetzt als Mulden-Rigolen-System angelegt werden.

Mulden-Rigolen-System
Ein Mulden-Rigolen-System ermöglicht eine dezentrale Regenwasserbewirtschaftung auch bei ungünstigen Bodenverhältnissen. Die Niederschlagsabflüsse werden in Mulden-Rigolen-Elementen zwischengespeichert und in den Untergrund versickert. Diese Elemente werden über Rohrleitungen miteinander vernetzt, so dass überschüssiges Regenwasser gedrosselt abgeleitet wird.

Muldenbett
Das Muldenbett ist der Bodenkörper (Bodenspeicher), der unterhalb einer Versickerungsmulde liegt. In STORM© ist jedem Systemelement “Mulde” automatisch ein Systemelement Muldenbett zugeordnet.

Muldenüberlauf
Durch Anordnung eines Muldenüberlaufes kann die Mulde direkt, d.h. unter Umgehung des Muldenbettes, in ein nachfolgendes Element (i.d.R. eine Rigole) überlaufen. Der Überlauf springt bei Erreichen der Überlaufhöhe an.

Muldenverlust
Mulden (gemeint sind die Mulden, die zu Verlusten bei der Abflussbildung beitragen) werden in Abhängigkeit des Niederschlagsgeschehens e-funktional gefüllt. Während der Muldenauffüllphase vergrößert sich der intervallbezogene Abflussbeiwert vom Anfangs- zum Endabflussbeiwert. Für die maximale Muldenverlusthöhe werden in STORM© für verschiedene Flächenarten die in Tabelle 4.1auf Seite 4–1 zusammengefassten Werte vorgeschlagen.

Mutterbodenpassage
Die Versickerung des Niederschlagsabflusses durch das Muldenbett. Trägt maßgeblich zur Reinigung der Abflüsse bei.

Nettoniederschlag
Der Niederschlag, der in dem betrachteten Zeitraum nach Abzug der Verluste zum Abfluss kommt.

Netzstruktur
Die Verknüpfung der verschiedenen Elemente zu einem Entwässerungssystem.

Niederschlagshöhe
Die Menge an Niederschlag, die in einem bestimmten Zeitraum gefallen ist, angegeben in mm.

Niederschlagskontinuum
Längere Zeitreihen mit Niederschlagsdaten, meist gemessene Aufzeichnungen u.U. aber auch synthetische Reihen, werden als Niederschlagskontinuum bezeichnet. Sie dienen als Eingangsdaten für die Langzeit-Kontinuums-Simulation.

Obelisk
Ein Obelisk ist ein geometrischer Körper, dessen Grundflächen durch Rechtecke in parallelen Ebenen gebildet wird. Die einander

gegenüberliegenden Kanten haben gleiche Neigung gegen die Grundfläche, schneiden sich aber nicht in einem Punkt. In STORM© wird die Muldengeometrie durch die Form eines Obelisken entsprechendAbbildung 4-14 auf Seite 4–1 vorgegeben.

Oberflächenabfluss
Der oberiridsche Abfluss, der aufgrund von Niederschlägen nach Abzug der Verluste entsteht.

Plotting-Formel
Für häufigkeitstheoretische Aussagen wird die Wiederkehrzeit der einzelnen Regenereignisse mit der auf Seite 5–1 dargestellten Plotting-Formel geschätzt. Die Formel für die Schätzung der Wiederkehrzeit beruht auf der Annahme, dass die berechneten Werte entsprechend einer Exponentialverteilung streuen.

Rauhigkeit
Unter der Rauhigkeit (mm) wird die betriebliche Rauhigkeit nach dem ATV Arbeitsblatt A110 verstanden. In Abhängigkeit von verschiedenen Kanalarten ergeben sich folgende pauschale, werkstoffabhängige Werte für die betriebliche Rauhigkeit:

- Drosselstrecken und Druckrohrleitungen kB = 0,25 mm
- Düker und Reliningstrecken ohne Schächte kB = 0,25 mm
- Transportkanäle mit Schächten kB = 0,50 mm
- Sammelkanäle und Sammelleitungen mit Schächten kB = 0,75 mm
- Sammelkanäle und -leitungen mit Sonderschächten kB = 1,50 mm

Regenrückhaltebecken
Regenrückhaltebecken dienen der Abflussdämpfung im Trennsystem. Eine Versickerung erfolgt in diesen Anlagen i.d.R. nicht. Regenrückhaltebecken können separat als zentrale bzw. semizentrale Entwässerungselemente oder in Kombination mit dezentralen Regenwasserbewirtschaftungsmaßnahmen angewendet werden.

Regenwasserbedarf

Die jährliche Menge an Zisternenwasser, die zur Abdeckung des gewünschten Verbrauchs erforderlich ist.

Regenwasserertrag
Die jährliche Menge an Zisternenzulauf, die zur Abdeckung des gewünschten Verbrauchs verfügbar ist.

Rigole
Eine Rigole ist ein, mit porösem Material (z.B. Kies), gefüllter Graben. Das zufließende Regenwasser wird in den Poren der Kiespackung zwischengespeichert und entleert sich über die Versickerung in den anstehenden Boden. Zum Schutz gegen den Eintrag von Feinstoffen sowie das Eindringen von Pflanzenwurzeln in den Porenraum wird die Rigole allseitig mit einem hochfesten Geotextil ummantelt.

Rigolenfüllmaterial
Das Material, mit dem die Rigole gefüllt wird. Um ein großes Speichervolumen zur Verfügung zu stellen, sollte es ein ausreichend großes Porenvolumen aufweisen. Feinkornanteile sollten möglichst gering gehalten werden, um eine Verschlickung zu verhindern. Mögliche Füllmaterialien sind Kies (16/32mm) oder auch Lavagranulat.

Rigolenüberlauf
Durch Anordnung eines Überlaufes kann die Rigole direkt, d.h. unter Umgehung der Drossel, in ein nachfolgendes Element (i.d.R. eine Verdingungsleitung oder eine andere Rigole) überlaufen. Der Überlauf springt bei Erreichen der Überlaufhöhe an.

Seriensimulation
Im Unterschied zur Kontinuumssimulation, werden bei der Seriensimulation mehrere Regenereignisse nacheinander simuliert. Trockenphasen bleiben unberücksichtigt. Im Unterschied zum Konzept des Bemessungsregens, werden die Ergebnisse statistisch ausgewertet.

Speicherelemente
In STORM© der Oberbegriff für die Entwässerungselemente, die der Zwischenspeicherung von Niederschlagsabflüssen dienen.
Speicherkoeffizient
Der Speicherkoeffizient (-) gibt den Anteil des effektiven Speichervolumens des Rigolenkörpers, der vom Rigolenfüllmaterial abhängt, wieder. Er fasst die Zwischenräume zwischen den Materialkörnern der Schüttmaterialien und eventuell vorhandenePorositäten der Körner zusammen. Werte für Speicherkoeffizienten können HÖLTING (1989) als nutzbare Porosität von Böden entnommen werden:

- Mittelkies 14 – 24 Vol-%
- Feinkies 15 – 25 Vol-%
- Kiesiger Sand 16 – 28 Vol-%
- Grobsand 15 – 30 Vol-%
- Mittelsand 12 – 25 Vol-%
- Feinsand 10 – 20 Vol-%
- Ton < 5 Vol-%

Baustoffe, die mit einer definierten Kornverteilung hergestellt werden, haben höhere Speicherkoeffizienten, wenn sie eine gleichförmige Kornverteilungskurve (u < 5) aufweisen. Nach SCHULTZE/MUHS (1967) können z.B. folgende Werte für den Porenanteil genannt werden:

- Grobkies 30 - 38 Vol-%
- Kiessand (u > 10) 25 - 40 Vol-%
- Sand (u < 5) 36 - 43 Vol-%

Speichervolumen
Das effektive Speichervolumen, das in einem Speicherelement zur Zwischenspeicherung von Niederschlagsabflüssen zur Verfügung steht.

Systemelemente
In STORM© der Oberbegriff für die hydrologischen Elemente, die zur Simulation des Niederschlags-Abfluss-Prozesses benötigt werden.

Tagesgang
Der Berechnung der Verdunstung für jedes Zeitintervall des Jahresganges liegt zusätzlich ein mittlerer Tagesgang zugrunde. Die implementierten

Standardwerte für diesen Tagesgang sind in Abbildung 4–1 auf Seite 4–1 grafisch dargestellt.

Translation
Geradlinig fortschreitende Bewegung eines Körpers. Die Abflüsse der oberhalb liegenden Speicherelemente werden durch Translation an unterhalb liegende Systemelemente weitergegeben.

Trockenphase
Der Zeitraum zwischen zwei Niederschlagsereignissen. Bei der Kontinuumssimulation werden Trockenphasen modelliert, um das Abtrocknen der Oberflächen und die Restentleerung von Speicherelementen zu berücksichtigten.

Überlauf
Mulden, Rigolen, Zisternen und Regenrückhaltebecken weisen Überläufe auf, um Zuflüsse, die nicht abgeführt bzw. versickert und nicht zwischengespeichert werden können, in nachgeschaltete Elemente zu entlasten. Der Überlauf springt bei Erreichen der Überlaufhöhe an.

Überlaufereignis
Der Zeitraum vom Beginn des Anspringens des Überlaufs bis zum Ende. In STORM© werden während eines Überlaufereignisses z.B. der max. Überlauf und die Überlaufmenge protokolliert. Die Liste der Überlaufereignisse ist Grundlage der statistischen Auswertung.

Überlaufhäufigkeit
Die mit der statistischen Auswertung berechnete Wiederkehrhäufigkeit, mit der der Überlauf eines Speicherelementes anspringt. Die Überlaufhäufigkeit ist Grundlage für die Bemessung des Speicherelementes.

Überlaufhöhe
Der Wasserstand in einem Speicherelement, ab dem der Überlauf „anspringt“.

Überlaufkennlinie
Die Überlaufkennlinien beschreiben die Überlaufcharakteristik von Zisternen, Mulden,Rigolen und Regenrückhaltebecken in Abhängigkeit vom Wasserstand. Der Überlauf springt bei Erreichen der Überlaufhöhe an.

Überlaufleistung
Die Abflussmenge pro Zeiteinheit, die über den Überlauf abgeführt werden kann. Die Überlaufleistung sollte i.d.R. so gewählt werden, dass nach Erreichen der Überlaufhöhe kein weiterer signifikanter Einstau im Speicherelement auftritt.

Überlaufvolumen
Die Wassermenge, die während eines Überlaufereignisses über den Überlauf abgeführt wurde. Das Überlaufvolumen ist Grundlage für die Bemessung des Speicherelementes.

Überstau
Wasserstände, die über die planmäßige Überlaufhöhe bzw. Tiefe des Speicherelementes hinaus auftreten.

Überstauvolumen
Die Wassermengen, die über das planmäßige Speichervolumen hinaus (vorgegeben durch die Überlaufhöhe bzw. Tiefe) im Speicherelement zwischengespeichert werden.

Verbindungsleitung
Verbindungsleitungen dienen im Programm STORM© der Verknüpfung von Systemelementen und können eine zeitliche Verzögerung des Abflusses (Translation) bewirken. Damit ist es möglich die Fließzeiten zwischen den Systemelementen beim Simulationsprozess zu berücksichtigen.

Verdunstung

Die Verdunstung ist der sich unterhalb des Siedepunktes vollziehende Übergang einer Flüssigkeit (Wasser) in den gasförmigen Zustand (Wasserdampf). Die Verdunstung ist ein wichtiges Glied im Kreislauf des Wassers.

Verdunstungsfaktor
Zur Berechnung der Verdunstung wird programmintern ein mittlerer Tages- und Jahresgang zugrundegelegt. Für eine potentielle Jahresverdunstungshöhe von 657 mm beträgt der Verdunstungsfaktor 1.0 (-). Durch Angabe einer Jahresverdunstungshöhe ^{1} 657 mm im Dialogfenster „Eigenschaften Verdunstung“ vergrößert bzw. verkleinert sich der programmintern verwendete Verdunstungsfaktor entsprechend.

Verdunstungsrate
Die Verdunstung innerhalb eines Zeitintervalls. Wird meist in l/d angegeben.

Verdunstungsverlust
“Verluste” die dem Niederschlag beim Prozeß der Abflussbildung an der Oberfläche entstehen und den oberirdischen Abfluss verringern.

Versickerungskennlinie
Die Versickerungskennlinien stellen die Versickerungsfläche der Entwässerungselemente Mulde bzw. Rigole in Abhängigkeit vom Wasserstand dar.

Versickerungsleistung
Die Versickerungsmenge, die während eines Zeitintervalls von einer Mulde bzw. einer Rigole versickert werden kann (in l/s).

Volumenkennlinie
Die Volumenkennlinien stellen das effektive Speichervolumen der Entwässerungselemente Zisterne, Mulde,Rigole bzw. Regenrückhaltebecken in Abhängigkeit vom Wasserstand dar.

Wiederkehrhäufigkeit
Die statistische Häufigkeit, mit der ein Ereignis (z.B. das Überlaufen einer Mulde) auftritt, angegeben in Anzahl pro Jahr. Der Kehrwert der Wiederkehrhäufigkeit ist die Wiederkehrzeit, d. h. die Zeit die statistisch gesehen zwischen zwei Ereignissen liegt.

Zähigkeit
Die Zähigkeit (Viskosität, innere Reibung) ist diejenige Eigenschaft eines flüssigen oder gasförmigen Mediums, die bei Deformation das Auftreten von Reibungsspannungen zusätzlich zum thermodynamischen Druck hervorruft, die einer Verschiebung von Flüssigkeits- oder Gasteilchen relativ zueinander entgegenwirken.

Cistern
Tanks which collect stormwater runoff from roofs and special collector surfaces and store the water for household use.

4.5 Warnings

While working with STORMİ, you may get the following warnings that are shown in the dialog window shown here:

Figure 6-1: Dialog window for displaying warnings

- *"The system was changed! Should the calculation results be deleted ?"*
- *"To change the element name, the dialog must be closed !"*
- *"Do you want to save changes ?"*
- *"Do you want to refresh the references to this object ?"*
- *"Do you really want to cancel the simulation ?"*
- *"Automatic calculation of characteristic curve ? Manual changes will be lost!"*
- *"RTF file already exists ! Overwrite the file ?"*
- *"To show the results you have to choose an element !"*

4.6 Error Messages

While working with STORMİ you may receive the following error messages, which are shown in a dialog window like this:

Figure 6-2: Dialog window for showing error messages

- *"Runoff formation parameter set ... is not assigned a rain gage!"*
- *"Runoff formation parameter set ... is not assigned an evaporation element!"*
- *"Discharge characteristic curve for the element ... could not be assigned!"*
- *"The calculation sequence cannot be carried out! Loop!"*
- *"The calculation sequence cannot be carried out! Empty character string!"*
- *"File formats of the parameter and system files do not match!"*
- *"File formats before version 2.0 are not supported!"*
- *"Date is not valid!"*
- *"Trench throttle destination not found!"*
- *"The element ... is not assigned an infiltration surface!"*
- *"The element ... is not assigned an evaporation element!"*
- *"False type of overflow in the STORM system file!"*
- *"Error while reading the file ..."*
- *"Error while writing file ..."*
- *"The surface ... is not assigned a runoff formation parameter set!"*
- *"The surface ... is not assigned a rain gauge!"*
- *"In this version only one rain gauge is permitted!"*
- *"No runoff formation parameter set available!"*
- *"No rain gauge available!"*
- *"No system element available!"*
- *"Characteristic curve ... does not have a supporting link!"*
- *"Read error in the STORM system file!"*

- *"Swale is not assigned a soil storage!"*
- *"STORM system file ... not found!"*
- *"Name cannot be blank!"*
- *"Name is already assigned!"*
- *"Not sufficient storage space available!"*
- *"Element cannot be added!"*
- *"Element name ... is already assigned!"*
- *"Element name may not be blank!"*
- *"Rain gauge file could not be opened!"*
- *"Rain gauge file! False number of comment lines!"*
- *"Rain gauge file! Date of the data record from ... causes errors!"*
- *"RTF file could not be created!"*
- *"Simulation cannot be executed!"*
- *"Simulation end occurs before its beginning!"*
- *"Depth of the element ... may not be smaller than zero!"*
- *"Overflow characteristic curve for the element ... could not be assigned!"*
- *"Volume of the element ... may not be small than zero!"*
- *"Volume characteristic curve for element ... could not be assigned!"*
- *"Value(s) in characteristic curve ... are negative!"*
- *"Cistern has not been assigned a withdrawal!"*