HYBEKA 8

Hydraulic Calculation
of Sewage Treatment Plants

SHORT DESCRIPTION

Version 8
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Contents

1 Background

Hydraulic calculation is one of the most important engineering tasks in planning a sewage treatment plant. It covers, for example, the

- correctly leveled allocation of the different structures of a sewage treatment plant and their trouble-free hydraulic functioning
- minimization of flow-level losses and thus of plant operating costs
- optimization of the altitude (height level) between inlet channel and receiving water
- extension of existing plants through additional cleaning stages and their hydraulic integration in predefined height ratios

Calculation is to be carried out for different flows (night, dry weather and stormwater flow), and often for many normal and special operational events. This is particularly time consuming for conventional processing, especially in the planning stage, as the dimensions of the connecting flumes and pipes and the conduits often change, and the hydraulic longitudinal profile must be adjusted repeatedly.

The DWA Technical Committee 2.11 "Design and Construction of Sewage Treatment Plants" (DWA - German Association for Water, Wastewater and Waste) deals with the development of recommendations that found a certain resolution in 1995 with the submission of the technical sheet A 106 "Design and Planning of Waste Water Treatment Plants". The technical sheet describes, in note form, the need and the requirements for detail and quality in hydraulic calculation at the various planning stages, but does not go into detail on the calculation itself. For this reason, **Working Group 2.11.1 "Hydraulic Calculation of Sewage Treatment Plants"** was promptly founded. Its members address the content and basics of sewage treatment plant calculation through publications and regular seminars (e.g. DWA seminar no. 1270).

The work of planning engineers has been made significantly easier and clearer with the wide availability of IT in the area of hydraulic calculation today. Consequently, there is now more time for designing conceptually correct and hydraulically sound plants. IT enables considerable timesaving even for smaller sewage treatment plants.

The engineering firm Brandt·Gerdes·Sitzmann Wasserwirtschaft Ltd., Darmstadt, has undertaken to

- develop the concept for a user-friendly and practical IT programming system for hydraulic sewage treatment plant calculation
- carry out the required programming and test work, and
- introduce and make the IT program system available to the public.

Through the cooperation between the members of DWA working group 2.11.1, there is a close relationship with DWA concepts, such that the completed IT program system rounds off the working group's endeavor.

The IT program system

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provides engineers a convenient planning tool which determines the entire course of water level, pressure and energy lines in the plant in a single calculation, even for very large and multi-line plants. Various operating conditions and variants can be calculated quickly and clearly. The positive experiences of many users from engineering firms and colleges confirm the chosen concept.

2 Program structure

2.1 Data input

Geometrical and hydraulic information must be provided for the calculation of a sewage treatment plant with HYBEKA. The user enters the required data via the user interface HYBEKA8w, in four thematically structured input masks.

- **Flow path/system flow scheme**
  logical linking of the sewage treatment plant elements, wastewater and sludge flow paths

- **Geometry**
  Element dimensions, e.g. of base heights, flume cross sections, pipe diameters, roughness

- **Hydraulic losses**
  Loss and overflow coefficients, e.g. for basin inlets, bends, toothed edges

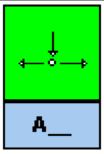
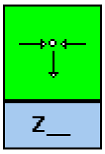
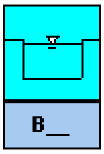
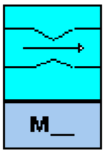
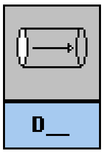
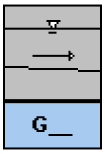
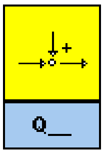
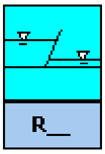
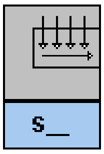
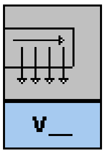
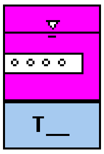
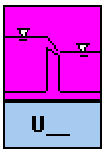
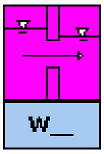
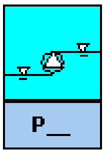
- **General data**
  Variant identification, discharges, inlets and outlets, minimum and maximum velocities, receiving water level

This data structure takes into account that the various input data are often subject to change during planning. This is very advantageous when using the IT program system:

- If dimensions change, only corrections to the geometry need be carried out (flows, flow paths, loss coefficients do not change as a rule).
- For different operational events, only general data needs to be adjusted (all remaining data remains unchanged).
- For plant extensions, only the added elements need to be inserted into the existing data.

When setting up the input data, the sewage treatment plant is subdivided by the user into hydraulic system elements as with a conventional calculation. The experiences of many users show that with these elements almost all calculation cases that can occur for a sewage treatment plant are covered.

Note: The identifier (1st capital initial character) of an element as it is shown in the pictogram in the following table is only self explaining in connection with the German word for the hydraulic element type. The identifier is required for programming purposes and may not be changed. In the following table you can find the German word and the English translation.

Picto-gram	Element type	Description	Picto-gram	Element type	Description
	**A**ufteilung Division	Branching into flow channels		**Z**usammenfluss Confluence	Merging of flow channels
	**B**ecken Basin	(large) transport route		**M**essstelle Measuring flume	here: only Venturi flume
	**D**ruckrohr (Pressure) pipe	Transport route with closed pro-file		**G**erinne Flume	Transport route with open pro-file
	**Q**zu/**Q**ab Qin/Qout	External inflow/outflow		**R**echen Screen	screen, trash rack
	**S**ammelrinne Collecting flume	Flow increase along flow di-rection		**V**erteilrinne Distribution flume	Flow decrease along flow di-rection
	**T**auchrohr Submerged pipes	Basin outlet with submerged pipes		**U**eberfall overfall	Rectangular weir, toothed weir
	**W**and Inlet/outlet wall	Wall-like cross section with openings		**P**umpe Pump	here: only pump pit

2.2 Calculation procedure

The input data collected via the **HYBEKA8w** user interface is stored in an **ACCESS** database. This is read by the calculation program **HYBEKA**.

Before actual calculation, **HYBEKA** checks the input data for completeness and plausibility. At the same time, the specified volume flows are balanced and the elements' logical connection is assessed. Detailed log files contain references to erroneous entries and to warnings.
Hydraulic calculation is based on generally recognized calculation procedures for technical hydraulics, as well as further methods for the calculation of collecting and distribution flumes and immersion tubes. These basics are described in detail in the program documentation. The following points should be highlighted:

- Water level progression along a flume is calculated in sections any cross sections (also for partially filled closed profiles). Here, the program takes into account that the often-accepted special case of "normal discharge" practically never occurs in sewage treatment plants.

- Water amounts are divided by specified division ratios or iteratively by the actual hydraulic realities. The case just mentioned is effectively incalculable using conventional manual calculation, but is obviously of particular interest for multi-line plants and for the evaluation of special operational cases (e.g. for revisions).

- Losses due to cross sectional contractions and extensions are automatically calculated in accordance with Borda-Carnot. This represents a considerable work simplification for the user, since most cross-sectional transitions (e.g. piping-basin, flume-piping) are correctly calculated without needing to specify additional loss coefficients.

- Existing hydraulic flow control in sewage treatment plants due to overfall sills and/or pumping stations are only taken into account by HYBEKA if they are actually hydraulically efficient. If, due to e.g. a high-water level of the receiving water, part of the plant is backed up and overfalls are submerged, this is handled automatically in the calculation (including generation of notes for the user).

Results output

The results (“ERG”) calculated by **HYBEKA** are output to an ACCESS results database and to an ANSI table. All information for the hydraulic longitudinal profile is included for each element:

- Element identification, line number, discharge
- Length, invert heights and flume depths
- Flow depths, water levels and energy levels
- Wetted cross section and flow velocity
- Hydraulic losses (divided into continual and individual losses)
- Notes on flow-related peculiarities

The optional brief summary (“ERK”) only contains results for the elements previously selected by the user. Further outputs of results contain special information for divisions and confluences (QVE, division of flows). Logs (“PKL”) draw the user's attention to – if present – input errors and peculiarities. If required, special results, e.g. for immersion pipes, are also shown. The detailed results make the calculation easily understandable and checkable for the regulatory authorities.

3 Field of application

The chosen concept enables use of the IT program system both as a planning tool in engineering firms, and as a checking tool for regulatory authorities.

3.1 Use as a planning tool

In planning sewage treatment plants and hydraulic calculation, conventional processing requires

- specification of operational cases and creation of the associated flow diagrams,
- subdivision of the plant into hydraulically isolated sections and single elements,
- derivation of geometric dimensions from the plans to be collected for the calculation, and
- assumption of hydraulic loss coefficients.

Apart from the creation of input files, applying HYBEKA requires no additional effort. Because the calculation results are generated very quickly, the effects of e.g. geometrical changes on the hydraulic longitudinal profile can be discerned immediately. Further adjustments can be made and then the calculation can be executed again. Comments output in the result printouts provide the user with further assistance.

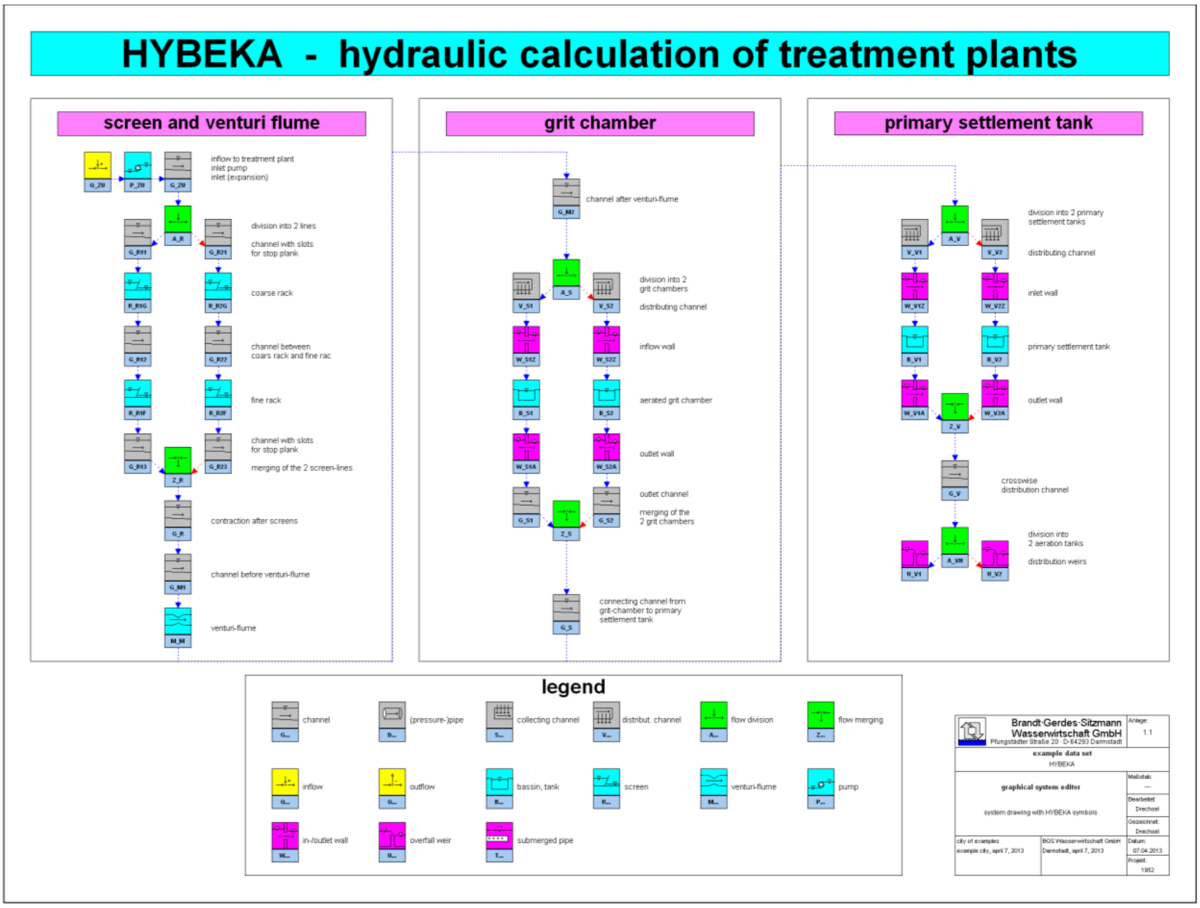
Simple operation, quick calculation and clearly laid out results with user notes all make **HYBEKA** suitable as a planning tool. During construction and even during plant operation, you can quickly evaluate changes to dimensions, loads, etc.

3.2 Use as a checking tool

Each step of hydraulic calculation with **HYBEKA** can be easily understood and checked by regulatory authorities thanks to the clear input and output structure. All hydraulics fundamentals correspond to the considerations of the **DWA Working Group 2.11.1 "Hydraulic Calculation of Sewage Treatment Plants"** and are detailed in the manual.

The **HYBEKA** program system is available to various regulatory authorities for checking the hydraulic calculation of sewage treatment plants. Responsible officials can then evaluate the effects of e.g. increased flows, higher receiving water levels, initially unconsidered revision cases etc.

4 Example sewage treatment plant



Input data and results from an example sewage treatment plant are explained in detail in the comprehensive program documentation. To achieve maximum compatibility and flexibility, besides the Access database, all input and output data is also available in ANSI format. Data is input directly into the database via the user interface using simple and clearly structured input masks.

Because of the concept's flexibility, input data can also be created with any text editor. The data must only be saved as ANSI code for further processing, and imported into the database.

Before a hydraulic calculation can be carried out with **HYBEKA**, the "sewage treatment plant" system must be stripped down into its separate hydraulic elements. To be able to distinguish the individual elements, identifiers are added which may consist of up to 12 alphanumerical characters. The first character is reserved for the element type; the remaining 11 characters can be freely selected by the user.

Examples:

BA3D21

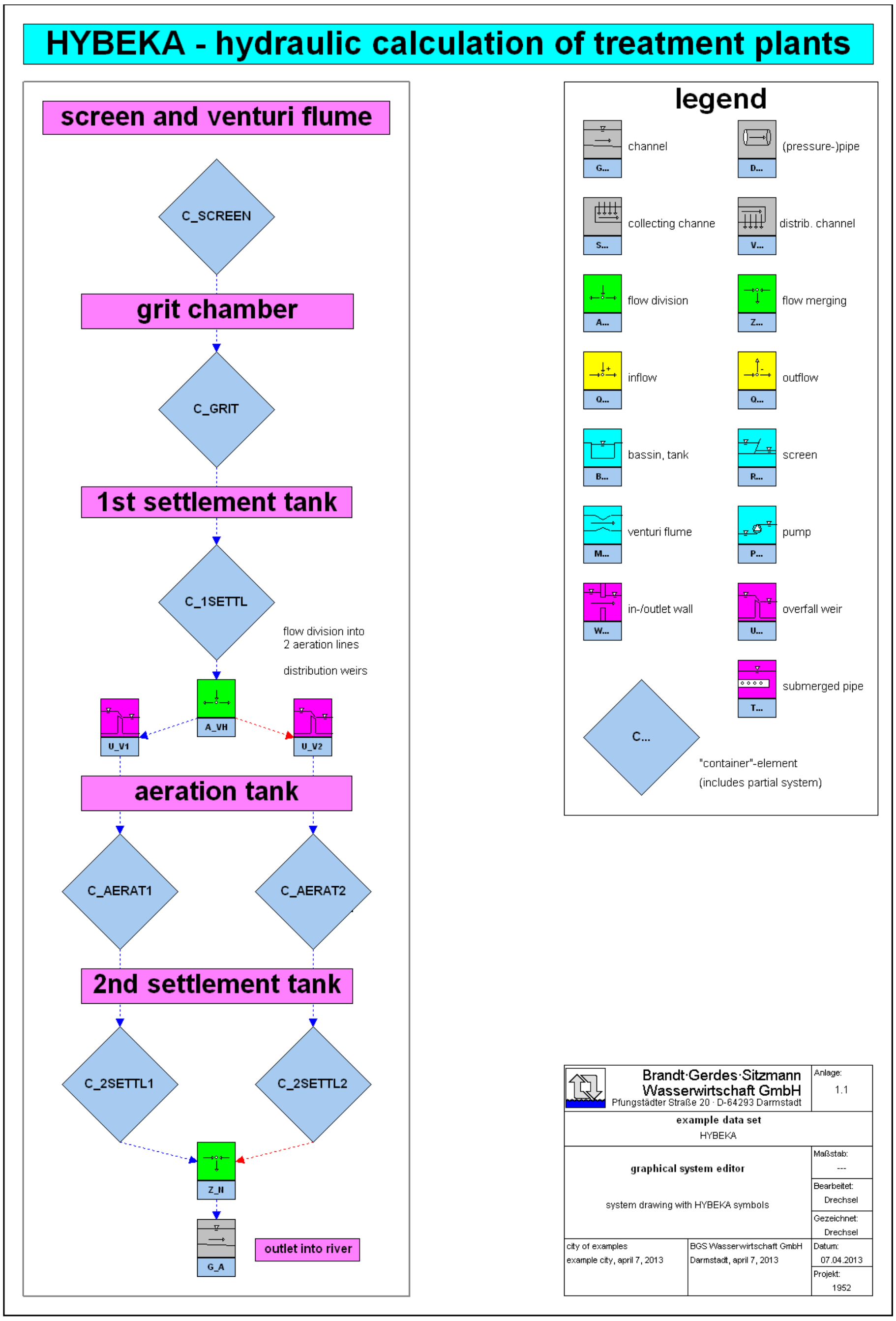
1st character	element type B → **B**asin
2nd character	**A**eration unit
3rd character	**3rd** line
4th character	**D**enitrification basin
5th character	**2nd** step
6th character	**1st** Basin

RS1F_1

1st character	element type R → Screen (**R**echen)
2nd character	**S**creen unit
3rd character	**1st** line
4th character	**F**ine screen
Other characters	sequential numbers

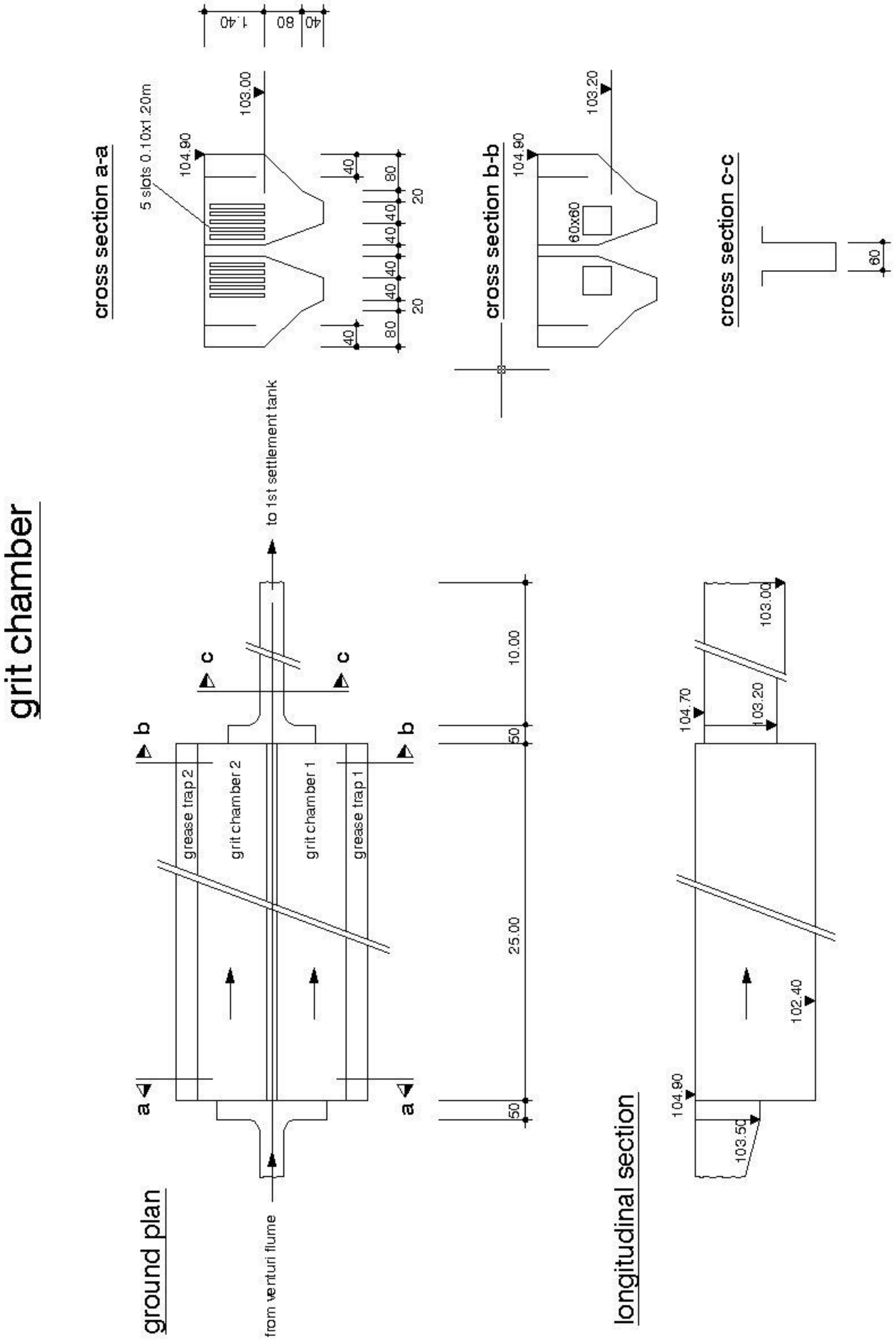
As an alternative to listing the entire sewage treatment plant in single file set, so-called "containers" can be created, each containing a special file set of a subsection. These containers are linked to each other for graphical editing, as with normal elements.

Using "containers" you can exchange similar (modular) subsections between various sewage treatment plants.



This brief description only deals with the "grit chamber" section with two parallel, ventilated chambers from the example sewage treatment plant. The inflow occurs over 5 vertical slots, outlet over a square opening. Immediately below the grit chambers, the two lines are reunited in a connecting flume.

The arrangement and dimensions are presented as longitudinal and cross sections on the following page.


grit chamber
cross section a-a
5 slots 0.10x1.20m
104.90
103.00
1.40
80
40
cross section b-b
60x60
103.20
cross section c-c
60
ground plan
from venturi flume
to 1st settlement tank
grease trap 2
grit chamber 2
grit chamber 1
grease trap 1
10.00
25.00
50
longitudinal section
104.70
102.40
103.50

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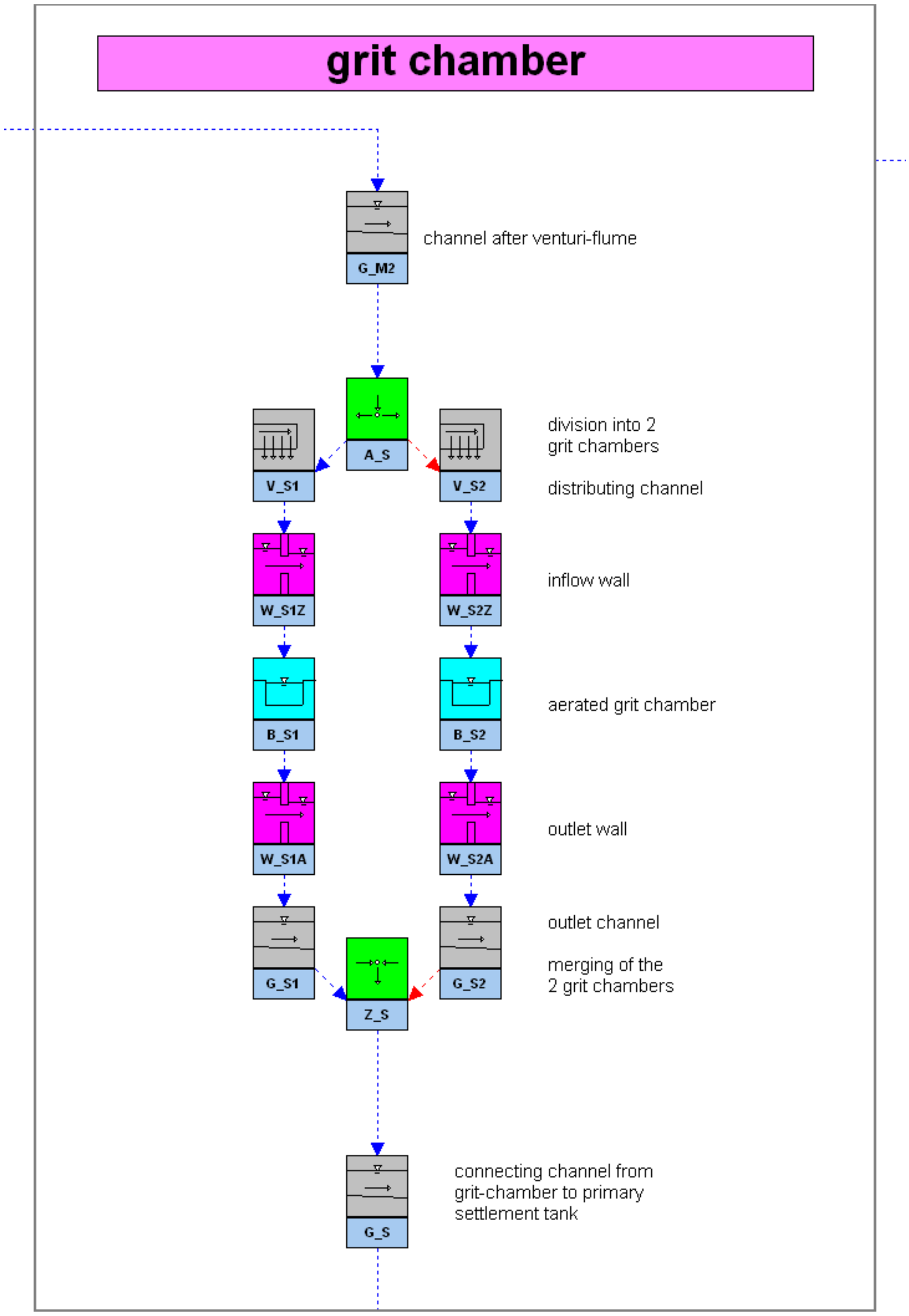
4.1 System flow scheme

Information on the sequencing for the individual elements must be input into the HYBEKA program. You can create a system flow scheme simply and clearly with the graphical system editor. The desired modules are placed in the diagram and connected with flow arrows. The created system plans can also be used in other documentation (plans or explanatory report). The following "grit chamber" section was entirely created in the system editor and was not subsequently edited.



The tabular system flow scheme needed for the program is updated based on the graphical information from the program in the background. The tabular flow path is presented for the grit chamber section as follows (here as an ANSI file):

flow path

```
example treatment plant HYBEKA                                                                     appendix  2
calculation of the complete system                                                                 Page      1
stormwater flow QRW                                                                                HYBEKA 8.00
===============================================flow path (WEG)============================================

I------------------------------------------I--------------I--------------I--------I---------I-------I-----I
I         S  y  s  t  e  m                 I Inlet        I Outlet       IDivisionI    Q    I Plot- I ERK I
I      Description           I Element     I   -          I   -          I %  l/s I   l/s   I path  I TAU I
I-+------------------------+I-+----------+-I-+----------+-I-+----------+-I------+-I-------+-I--+-+--I-+-+-I
I inflow to treatment plant I Q_ZU         I              I P_ZU         I        I  345.00 I       I     I
........
I channel after venturi     I G_M2         I M_M          I A_S          I        I         I       I E   I
I-+------------------------+I-+----------+-I-+----------+-I-+----------+-I------+-I-------+-I--+-+--I-+-+-I
I div. before grit chamber  I A_S          I G_M2         I V_S1         I  50.00 I         I       I E   I
I                           I              I              I V_S2         I  50.00 I         I       I     I
I distributing channel 1    I V_S1         I A_S          I W_S1Z        I        I         I       I E   I
I inlet wall 1              I W_S1Z        I V_S1         I B_S1         I        I         I       I E   I
I grit chamber 1            I B_S1         I W_S1Z        I W_S1A        I        I         I       I     I
I outlet wall               I W_S1A        I B_S1         I G_S1         I        I         I       I E   I
I outlet channel 1          I G_S1         I W_S1A        I Z_S          I        I         I       I E   I
I distributing channel 2    I V_S2         I A_S          I W_S2Z        I        I         I       I E   I
I inlet wall 2              I W_S2Z        I V_S2         I B_S2         I        I         I       I E   I
I grit chamber 2            I B_S2         I W_S2Z        I W_S2A        I        I         I       I E   I
I outlet wall 2             I W_S2A        I B_S2         I G_S2         I        I         I       I E   I
I outlet channel 2          I G_S2         I W_S2A        I Z_S          I        I         I       I E   I
I merging of grit chambers  I Z_S          I G_S1         I G_S          I        I         I       I E   I
I                           I              I G_S2         I              I        I         I       I     I
I channel after grit chamberI G_S          I Z_S          I A_V          I        I         I       I E   I
I-+------------------------+I-+----------+-I-+----------+-I-+----------+-I------+-I-------+-I--+-+--I-+-+-I
I divis. 1st settl. tank    I A_V          I G_S          I V_V1         I  50.00 I         I       I E   I
I                           I              I              I V_V2         I  50.00 I         I       I     I
........
I outlet channel to river   I G_A          I Z_N          I              I        I         I       I E   I
I-+------------------------+I-+----------+-I-+----------+-I-+----------+-I------+-I-------+-I--+-+--I-+-+-I
```

The meaning of each column is explained below.

Name	Meaning
Description	Element description
Element	System element identifier 1st character = element type, maximum 5 further alphanumeric characters for identification
Input	inlet element identifie with the exception of the 1st element must be specified for all elements, for confluences: identifier of the 2nd inlet in an additional line
Output	outlet element identifier must be specified for all elements; for divisions: identifier of the 2nd outlet in an additional line
Division	Discharge division in % of inflow or absolute in l/s. Unspecified: iterative division calculation.
Plot path	specification of the flow path to be followed as divided by the plot program, or the "switching off" of an element from the plot path.
Q	discharge in l/s
ERK/TAU	Taking into account the element in the *.ERK output file and creation of a special results printout for immersion pipes.

4.2 Element geometry

All required dimensions for the geometry data area are read from the site plans and sectional drawings (geometry of the elements). Data for all elements is input via the same uniform input mask, which can be opened either directly or by double-clicking the element in the graphical system editor. For the "grit chamber" section, the optional geometry ANSI file is presented as follows:

Geometry

```
example treatment plant HYBEKA                                                       appendix  3
calculation of the complete system                                                   Page      1
stormwater flow QRW                                                                  HYBEKA 8.00
====================================Geometry (GEO)===================================

I--------------I---------------------I----------I-----------------------------------I
I Element      ILongitudinal GeometryIhyd.lossesI Inlet    - Cross section - Outlet I
I              I    zo      zu      L  I  k     c  IT  hs    h     B   IT  hs    h     B   I
I--------------I---------------------I----------I-----------------I-----------------I
I   -          I   masl    masl     m  I  mm    -  I-  m     m     m   I-  m     m     m   I
I-+----------+-I-------+------+-----+I----+----+I+----+----+----+-I+----+----+----+-I
I Q_ZU         I  101.00              I 1.00     IK            0.80 I                  I
........
I G_M2         I  103.90 103.50  2.00I           IT      1.00 0.60 IT      1.40 0.60 I
I-+----------+-I-------+------+-----+I----+----+I+----+----+----+-I+----+----+----+-I
I A_S          I  103.50 103.50      I           IT      1.40 0.60 IT      1.40 0.50 I
I              I         103.50      I           I                 IT      1.40 0.50 I
I V_S1         I  103.50         1.10I           IT      1.40 0.50 I                 I
I W_S1Z        I  103.50             I           IT      1.40 1.10 I                 I
I B_S1         I  102.40        25.00I           IT      0.00 0.40 I                 I
I              I                     I           I       0.40 0.80 I                 I
I              I                     I           I       0.80 1.40 I                 I
I              I                     I           I       2.50 1.40 I                 I
I W_S1A        I  103.20             I           IT      1.70 1.00 I                 I
I G_S1         I  103.20         1.00I           IT      1.50 0.50 I                 I
I V_S2         I  103.50         1.10I           IT      1.40 0.50 I                 I
I W_S2Z        I  103.50             I           IT      1.40 1.10 I                 I
I B_S2         I  102.40        25.00I           IT      0.00 0.40 I                 I
I              I                     I           I       0.40 0.80 I                 I
I              I                     I           I       0.80 1.40 I                 I
I              I                     I           I       2.50 1.40 I                 I
I W_S2A        I  103.20             I           IT      1.70 1.00 I                 I
I G_S2         I  103.20         1.00I           IT      1.50 0.50 I                 I
I Z_S          I  103.20 103.20      I           IT      1.50 0.50 IT      1.50 0.60 I
I              I  103.20             I           IT      1.50 0.50 I                 I
I G_S          I  103.20 103.00 10.00I           IT      1.50 0.60 IT      1.70 0.60 I
I-+----------+-I-------+------+-----+I----+----+I+----+----+----+-I+----+----+----+-I
I A_V          I  103.00 103.00      I           IT      1.70 0.60 IT      1.70 0.50 I
I              I         103.00      I           I                 IT      1.70 0.50 I
........
I G_A          I  102.00        20.00I           IT      1.50 0.60 I                 I
I-+----------+-I-------+------+-----+I----+----+I+----+----+----+-I+----+----+----+-I
```

Name	Meaning
Element:	Identifier as in system flow scheme
Longitudinal section geometry:	
zo/zu	Canal bottom height above/below
L	Element length
Losses:	(Element-related information or details on calculation sections)
k	equivalent uniform grain roughness continual losses as per Prandtl-Colebrook or Manning-Strickler coefficient k_{st}
c	Carnot coefficient for calculating the transitional energy loss due to change of cross sections from one element to the next. Not specified: automatic loss calculation for sharp edged transition.
Cross section geometry:	cross section upstream (inlet) and downstream (outlet) Variously sized and styled cross sections can be specified here.
T	Canal bottom type of the flow cross section K Circular canal bottom T Linear canal bottom (trapezoidal cross section) hs Rise at closed cross sections
h, B	Value pairs of profile height and width. For divided cross sections: multi-line specifications. This kind of input considers all possible profiles occurring in sewage treatment plants. Simplified input for circular and linear outlines.

4.3 Additional information on losses

The Hydraulic Losses data input area records information on locally limited individual losses as well as special geometry data, if the geometry data is insufficient for the hydraulically necessary description of the relevant elements. For the "grit chamber" section, the optional HVE ANSII file is printed as follows:

Hydraulic losses

```
example treatment plant HYBEKA                                                               appendix  4
calculation of the complete system                                                           Page      1
stormwater flow QRW                                                                          HYBEKA 8.00
===========================================Head losses (HVE)===========================================


I-------------I----------------------------I----------------I----------I-------------------------I
I Element     I   Local losses  IC.DischargeI    Geometry    I No. Dist.I Comment                 I
I             I  hve IZeta1 Zeta2I   μ      n IT h,D    Bu    Bo  I  n     a  I                         I
I-------------I------I-----------I-----------I----------------I----------I-------------------------I
I   -         I   m  I   -     - I   -     - I-  m     m    m I  -    m  I                         I
I-+----------+-I----+-I----+----+-I----+----+-I+----+----+----+-I---+----+-I-+----------------------+I
........
I A_S         I      I 1.00 1.54 I           I                I          I 0.0 = Q1/Qtot division   I
I             I      I 0.92 1.20 I           I                I          I 0.2   symmetric          I
I             I      I 0.92 0.95 I           I                I          I 0.4   angle = 90 deg.    I
I             I      I 0.95 0.92 I           I                I          I 0.6   A1/Atot=0.8        I
I             I      I 1.20 0.92 I           I                I          I 0.8   Idelchik Diagr. 7-3I
I             I      I 1.54 1.00 I           I                I          I 1.0  (Idelchik Diagr. 7-1I
I W_S1Z       I      I 1.50      I           IT 1.20 0.10     I   5      I 5 vertikal slots         I
I W_S1A       I      I 1.50      I           IT 0.60 0.60     I   1      I square outlet opening    I
I W_S2Z       I      I 1.50      I           IT 1.20 0.10     I   5      I 5 vertikal slots         I
I W_S2A       I      I 1.50      I           IT 0.60 0.60     I   1      I square outlet opening    I
I Z_S         I      I 2.78 2.78 I           I                I          I 0.0 = Q1/Qtot merging    I
I             I      I 1.92 1.92 I           I                I          I 0.2   A1/Atot=0.75       I
I             I      I 1.50 1.56 I           I                I          I 0.4   without partition  I
I             I      I 1.56 1.50 I           I                I          I 0.6   angle = 90 deg.    I
I             I      I 1.92 1.92 I           I                I          I 0.8   Idelchik Diagr. 7-2I
I             I      I 2.78 2.78 I           I                I          I 1.0                      I
........
I-+----------+-I----+-I----+----+-I----+----+-I+----+----+----+-I---+----+-I-+----------------------+I
```

Name	Meaning
Element	Identifier as in system flow scheme
Local losses	
hve	Constant loss of energy height e.g. switch-on by waterlevel difference for screens
Zeta 1/2	coefficient ζ (Zeta) for loss of energy level
Coefficients	
μ	Overfall coefficient μ
n	Exponent for calculating reduction coefficient c
Geometry	Geometry of a single opening, tooth or contraction
T	Type of opening/contraction K = circular opening, T = trapezoidal opening
h,D	Height or diameter of the opening
Bu,Bo	Lower/upper width of the opening
No. n	Number of openings
Dist. a	Axial distance of the opening
Comment	Free text description of the selected values

4.4 General data

In addition to the previously listed data, various general details are required. For example, discharges and hydraulic constraints are entered here.

General data

```
example treatment plant HYBEKA                                  appendix  1
calculation of the complete system                              Page      1
stormwater flow QRW                                             HYBEKA 8.00
===========================Basic Parameters (ALL)===========================

Headlines                         : example treatment plant HYBEKA
---------                         : calculation of the complete system
                                  : stormwater flow QRW
Basic Settings
-------------------------------------------------------------------+-------+
Min. flow velocity................................(warning) (m/s) :     0.30
Max. flow velocity................................(warning) (m/s) :     1.50
Min. conduit width................................(warning)   (m) :     0.30
Max. conduit width................................(warning)   (m) :    10.00
Min. conduit height...............................(warning)   (m) :     0.30
Max. conduit height...............................(warning)   (m) :    10.00
Max. element length...............................(warning)   (m) :    50.00
Max. diff. of invert levels between in- and outlet (warning)  (m) :    15.00
Max. number of lines in *.ERG and *.ERK-file............... (> 60) :       70
Datum elevation of invert level for *.GEO-file............. (masl) :
Water level at calculation end............................. (masl) :

Flows (feed and take out)                                             l/s
-----------------------+----------+-+----------------------------+-------+
Feed at element         Q_ZU        inflow to treatment plant     :  345.00
Feed at element         Q_B1A1      internal recirculation (+)    :   50.00
Feed at element         Q_B1A2      recycle  sludge               :  100.00
Take out at element     Q_B1D1      internal recirculation (-)    :  -50.00
Take out at element     Q_B1N2      waste sludge N2 (-)           :   -3.00
Feed at element         Q_B2A1      internal recirculation (+)    :   50.00
Feed at element         Q_B2A2      recycle  sludge               :  100.00
Take out at element     Q_B2D1      internal recirculation (-)    :  -50.00
Take out at element     Q_B2N2      waste sludge N2 (-)           :   -3.00
Take out at element     Q_N1        activated sludge (-)          : -100.00
Take out at element     Q_N2        activated sludge (-)          : -100.00
```

Name	Meaning
headlines:	Text for more detailed description of the calculation variant appears in results printout
Basic settings:	Minimal/maximal permitted flow velocity Note in the results printout on overshooting/undershooting in a connecting element (flume, pressure pipe) Minimal/maximal flume width and height, maximal element length and difference invert level between in- and outlet level Details on overshooting/undershooting in a warning log to identify input errors Water level at end of calculation Initial value of the calculation at the lower end of the last calculation element
flows	For all "Q" elements of the flow path details in the ALL file: • “Feed” or “Take out” • Element identifier (as in flow path) • Text for more detailed description of the element • Inlet or outlet in [l/s] or [cbm/h]

4.5 Results

Calculation results are output as a database (MS Access) and as an ANSI file. The results render the relevant values of the water level calculation in a submittable and checkable form. With the results, the hydraulic longitudinal section of the plant can be drawn directly using the corresponding additional program. Presented below in turn is only the section of the results for the "grit chamber":

Detailed results file

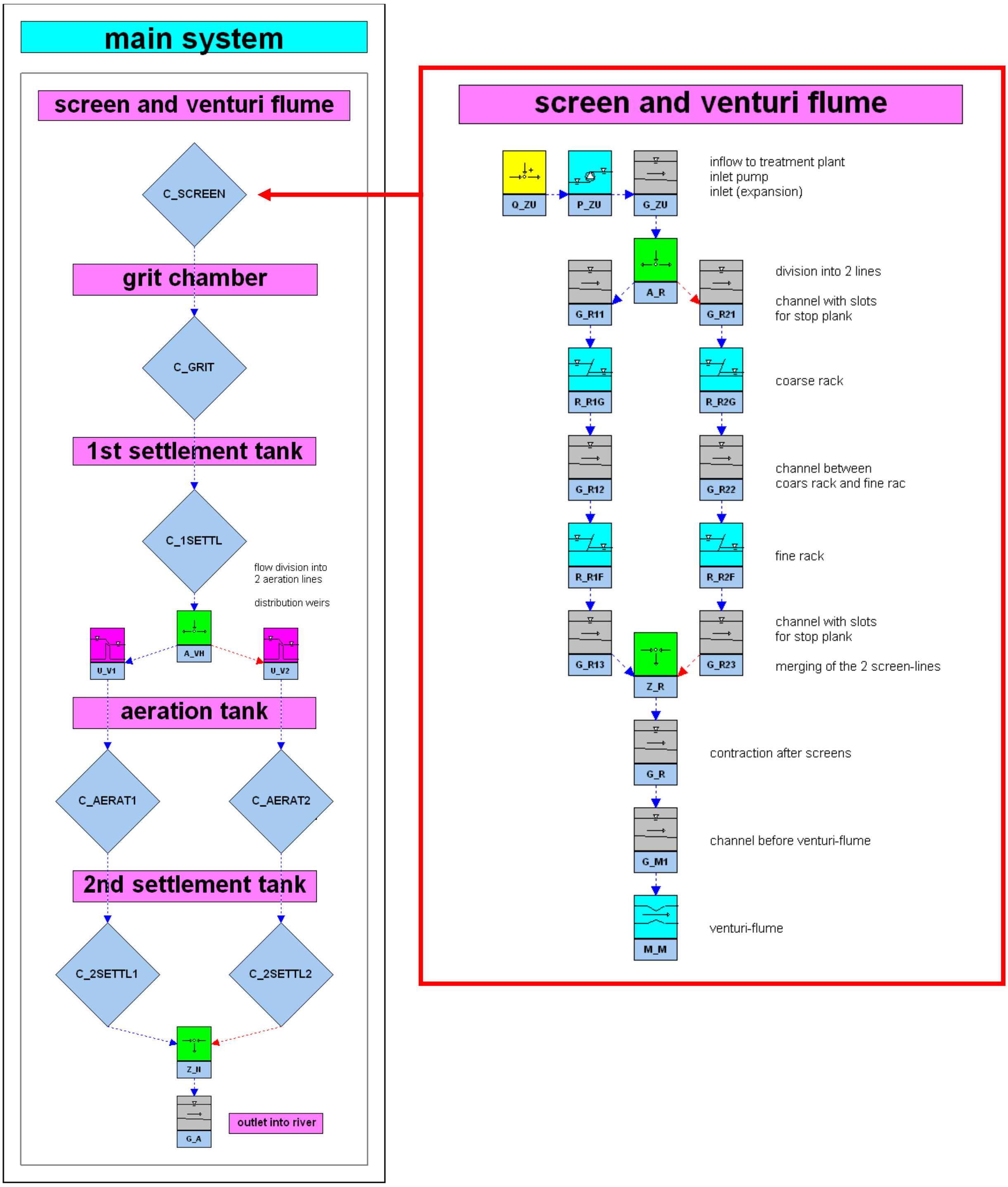
```
example treatment plant HYBEKA                                                                                  appendix   6
calculation of the complete system                                                                                  page   1
stormwater flow QRW                                                                                               17.04.2013
===================================================== Results (*.ERG) =====================================================
   (1)   (2)    (3)     (4)     (5)      (6)  (7)    (8)     (9)   (10)    (11) (12) (13)  (14)   (15) (16)      (17)
I-----------I--------I-------I-----------------------------------------------------------I-------------------I-------------I
I Element OrI Flow-  ILength I Invert   Board Water Water   Wetted  Flow   Energy Shear  I Hydraulic losses  I Comment     I
I        derI rate   Iof     I level    level level level   cross-  velo-  level  stress I Wall  Inst- Inter-I             I
I           I        IElementI                              section city                 I frict. all. sect. I             I
I           I  m3/s  I   m   I  masl      m     m     masl    m2     m/s     masl   N/m2 I  m       m     m  I             I
I-----------I--------I-------I-----------------------------------------------------------I-------------------I-------------I
I.........
I A_S      1I  0.345 I       I 103.500  1.40  0.69 104.187   0.41  0.84   104.223      oI     0.033/ 0.033   I             I
I          1I  0.173 I       I 103.500  1.40  0.68 104.176   0.34  0.51   104.189      oI              0.000 I             I
I          3I  0.173 I       I 103.500  1.40  0.68 104.176   0.34  0.51   104.189      oI              0.000 I             I
I V_S1     1I  0.173 I       I 103.500  1.40  0.68 104.176   0.34  0.51   104.189  0.72 oI 0.000 0.000       I             I
I          1I  0.086 I  0.55 I 103.500  1.40  0.69 104.186   0.34  0.25   104.189  0.18 oI              0.000 I       v     I
I        **I  0.000 I  1.10 I 103.500  1.40  0.69 104.189   0.34  0.00   104.189  0.00 oI                    I             I
I W_S1Z    1I  0.173 I       I 103.500  1.40  0.68 104.176   0.34  0.51   104.189      oI       0.007        I          FS I
I          1I        I       I 103.500  1.40  0.67 104.168   0.33  0.52   104.182      oI              0.014 I          FS I
I B_S1     1I  0.173 I       I 102.400  2.50  1.77 104.168   2.04  0.08   104.168  0.02 oI 0.000 0.000       I             I
I          1I        I 25.00 I 102.400  2.50  1.77 104.168   2.04  0.08   104.168  0.02 oI              0.000 I             I
I W_S1A    1I  0.173 I       I 103.200  1.70  0.96 104.157   0.36  0.48   104.168      oI       0.018        I             I
I G_S1     1I  0.173 I       I 103.200  1.50  0.94 104.144   0.47  0.37   104.151  0.37 oI 0.000 0.000       I             I
I          1I        I  1.00 I 103.200  1.50  0.94 104.144   0.47  0.37   104.151  0.37 oI              0.000 I             I
I V_S2     3I  0.173 I       I 103.500  1.40  0.68 104.176   0.34  0.51   104.189  0.72 oI 0.000 0.000       I             I
I          3I  0.086 I  0.55 I 103.500  1.40  0.69 104.186   0.34  0.25   104.189  0.18 oI              0.000 I       v     I
I        **I  0.000 I  1.10 I 103.500  1.40  0.69 104.189   0.34  0.00   104.189  0.00 oI                    I             I
I W_S2Z    3I  0.173 I       I 103.500  1.40  0.68 104.176   0.34  0.51   104.189      oI       0.007        I          FS I
I          3I        I       I 103.500  1.40  0.67 104.168   0.33  0.52   104.182      oI              0.014 I          FS I
I B_S2     3I  0.173 I       I 102.400  2.50  1.77 104.168   2.04  0.08   104.168  0.02 oI 0.000 0.000       I             I
I          3I        I 25.00 I 102.400  2.50  1.77 104.168   2.04  0.08   104.168  0.02 oI              0.000 I             I
I W_S2A    3I  0.173 I       I 103.200  1.70  0.96 104.157   0.36  0.48   104.168      oI       0.018        I             I
I G_S2     3I  0.173 I       I 103.200  1.50  0.94 104.144   0.47  0.37   104.151  0.37 oI 0.000 0.000       I             I
I          3I        I  1.00 I 103.200  1.50  0.94 104.144   0.47  0.37   104.151  0.37 oI              0.000 I             I
I Z_S      1I  0.173 I       I 103.200  1.50  0.94 104.144   0.47  0.37   104.151      oI       0.032        I             I
I          3I  0.173 I       I 103.200  1.50  0.94 104.144   0.47  0.37   104.151      oI       0.032        I             I
I          1I  0.345 I       I 103.200  1.50  0.90 104.098   0.54  0.64   104.119      oI              0.000 I             I
I G_S      1I  0.345 I       I 103.200  1.50  0.90 104.098   0.54  0.64   104.119  1.07 oI 0.004 0.000       I             I
I          1I        I 10.00 I 103.000  1.70  1.10 104.101   0.66  0.52   104.115  0.71 oI              0.000 I             I
.........
I-----------I--------I-------I-----------------------------------------------------------I-------------------I-------------I
Remarks:        0 Iteration steps
             ü    Channel overflow or underwater level higher than weir crown but total overflow
             u    Head water level under level of weir crown
             d    Pressure flow
             gr   Supercritical/torrential flow at lower cross section
             dE   No convergence of energy level in case of a given division of flow
             v/V  Minimum/maximum velocity warning
             uv   Submerged overflow at weir or no critical depth in venturi channel
             he   Difference of water levels for the water level control is insufficient
             FS   Gravity flow at element with closed cross section
             **   No flow at outlet of distribution or collection channel
             µ'   Submerged overflow calculated by weir formula
             µ    orifice with gravity flow calculated by sluice formula
============================================================================================================================
PROGRAMM HYBEKA (c) Brandt·Gerdes·Sitzmann Wasserwirtschaft GmbH, Darmstadt 2019                                HYBEKA 8.00
```

The table header contains the headings as specified by the general details, a variable attachment number, page numbering, and the date on which the file was created. The results for all the elements are listed in the order determined by the system flow scheme (one line each for the upper and lower cross section). Elements without linear development (overfalls , walls are only documented by one single cross section. Elements with a division or a confluence have up to four results rows.

Nr.	**Meaning of the colums**
(1)	Element identifier
(2)	Order of the flow line The order number identifies the different discharge lines in the plant (e.g. treatment lines, parallel chambers) beneath divisions
(3)	Discharge in cross section
(4)	Element length, or positioning
(5)	Canal bottom height
(6)	Canal bottom-related height of the cross section profile according to geometry
(7)	Calculated water level (canal bottom-related)
(8)	Calculated water level (in masl)
(9)	Flow cross section
(10)	Mean velocity
(11)	Energy level
(12)	shear stress on channel bottom
(13)	Identifier for open "o" or closed "g" profile
(14)	Continual losses
(15)	Individual losses in the element according to the specifics of the hydraulic losses (e.g.: bend losses)
(16)	Individual losses at the transition due to change of cross sections from one element to the next between in accordance with Borda-Carnot
(17)	Comments on characteristics of flow or calculation process (legend: footer text of the results file)

5 Assemblies / container

A sewage treatment plant may be divided into individual assemblies, so-called containers, that can be worked on separately. The containers are linked via a main-system (reference plan). There are file sets (database and system plan) respectively for the main-system and containers (C_SCREEN, etc.) which allow for composing alternatives of a sewage treatment plant in accordance with the modular design principle.



6 Additional programs

6.1 User interface

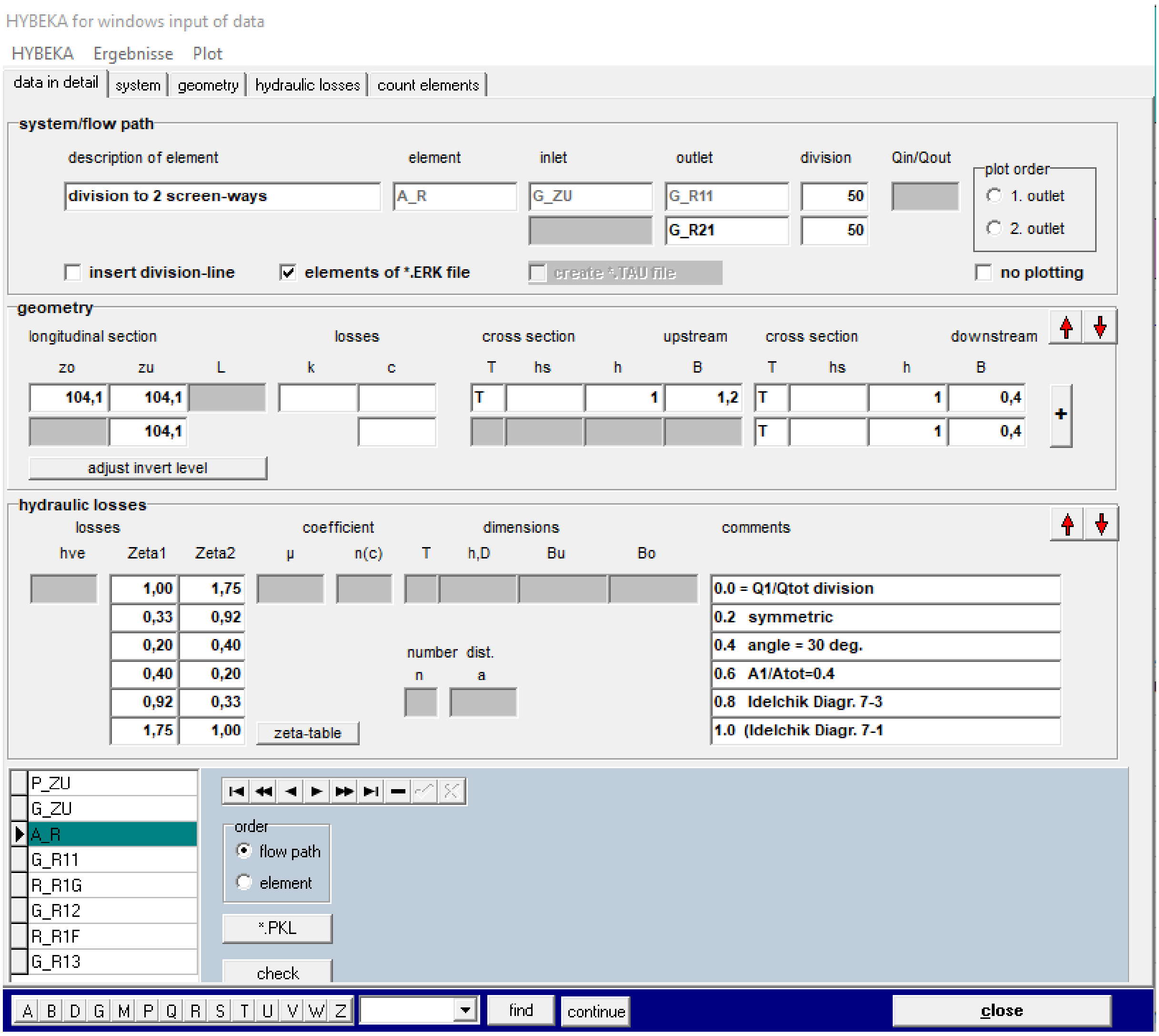
The **User interface** is designed for Windows™ operating systems and, allows convenient processing of HYBEKA projects. For the most part, using the program is self-explanatory. Any required information can be displayed in case of doubt via the help function. The functionality was organized to contain the necessary features and options for practical work. Care was taken to ensure that usage is as simple and clear as possible. Operation of the user interface assumes knowledge of basic Windows™ commands and conventions.
The following should be mentioned as special features:

- The graphical system editor enables you to easily and clearly describe the flow path through the sewage treatment plant. Thanks to additional graphical functionality (texts, legends, title blocks, graphics, frames) complete, print-ready system plans can be created directly with the system editor.

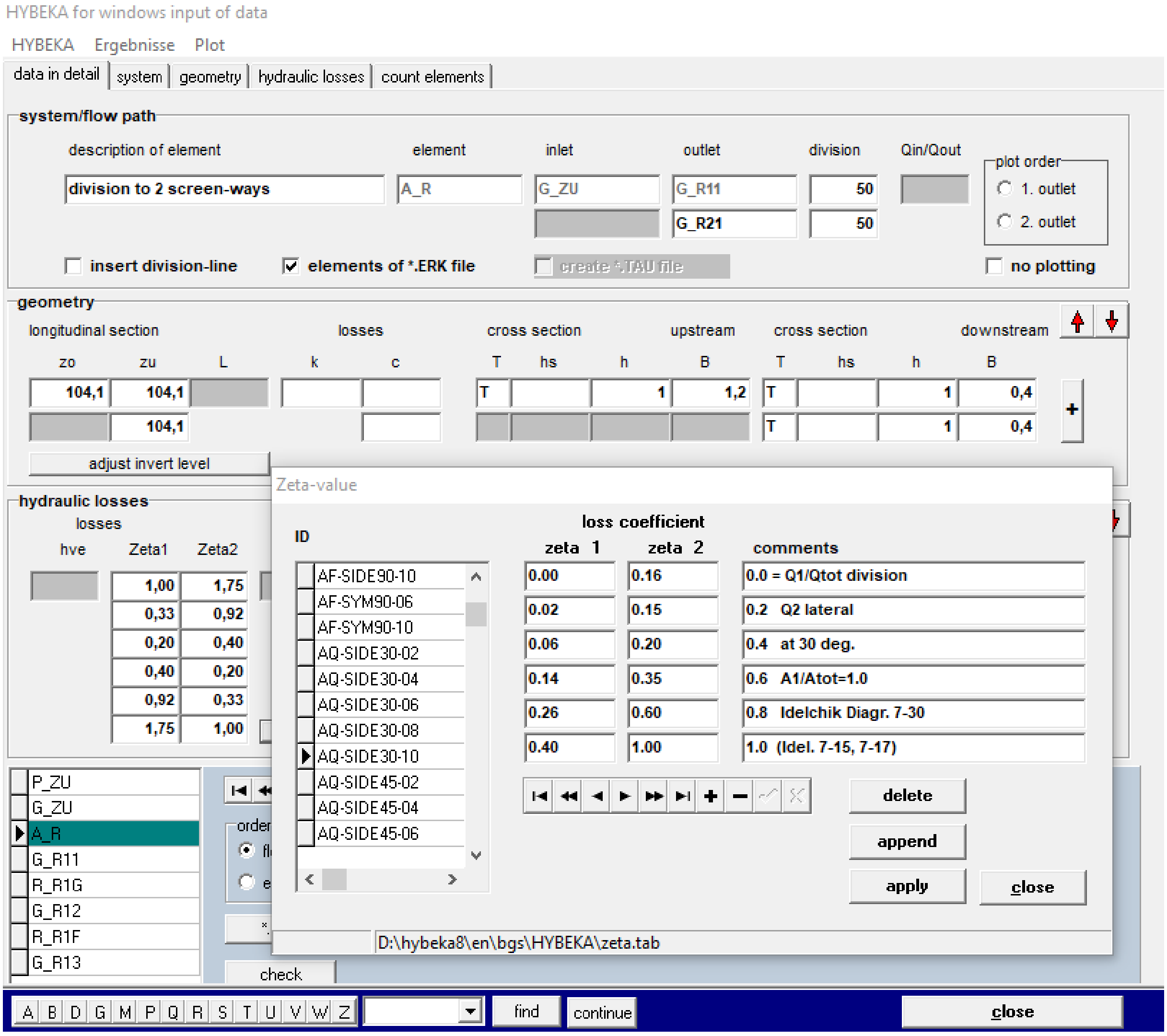
- While working with the HYBEKA program you may access a table which is part of the package and can be expanded by the user. It offers the possibility to easily and conveniently select or enter default values for loss coefficients (e.g. bends, divisions). Thus, you may enter your frequently used loss coefficients directly as default values without the need for literature research and laboriously entering the respective values into the input mask.

The following screen shots give an initial impression of the Windows™ user interface.

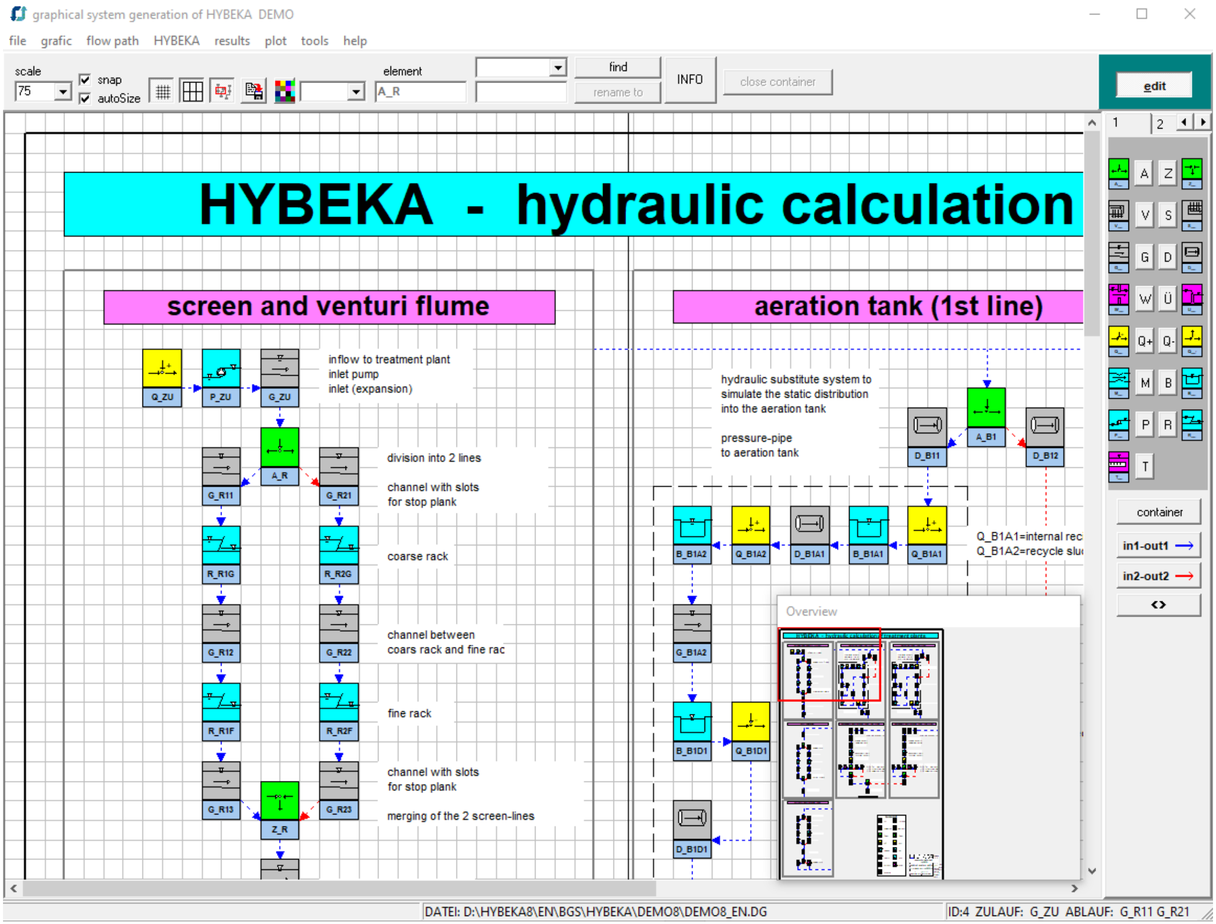
Data entry mask



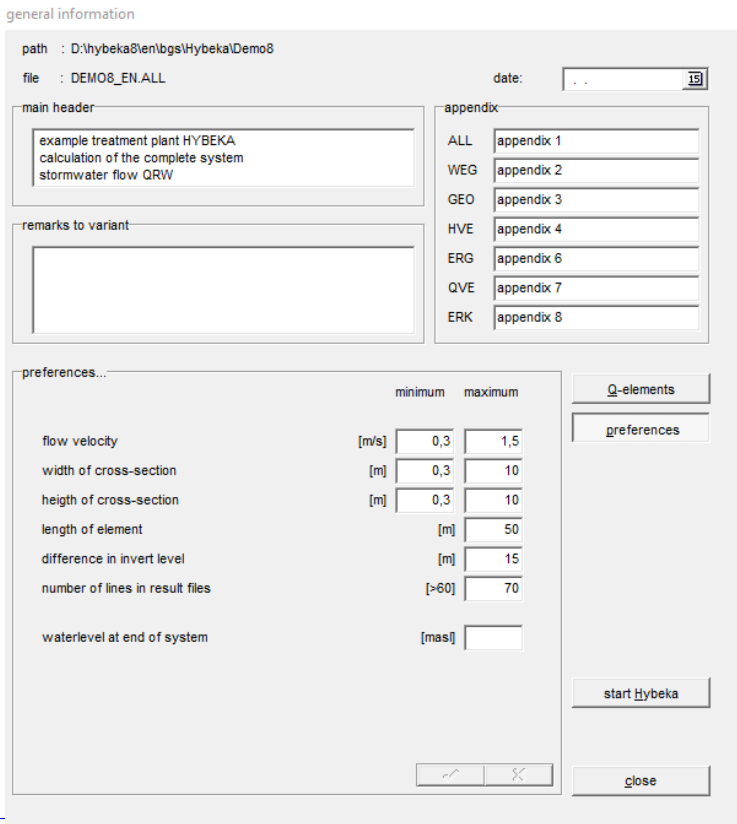
Data entry for loss coefficients



Graphical system editor

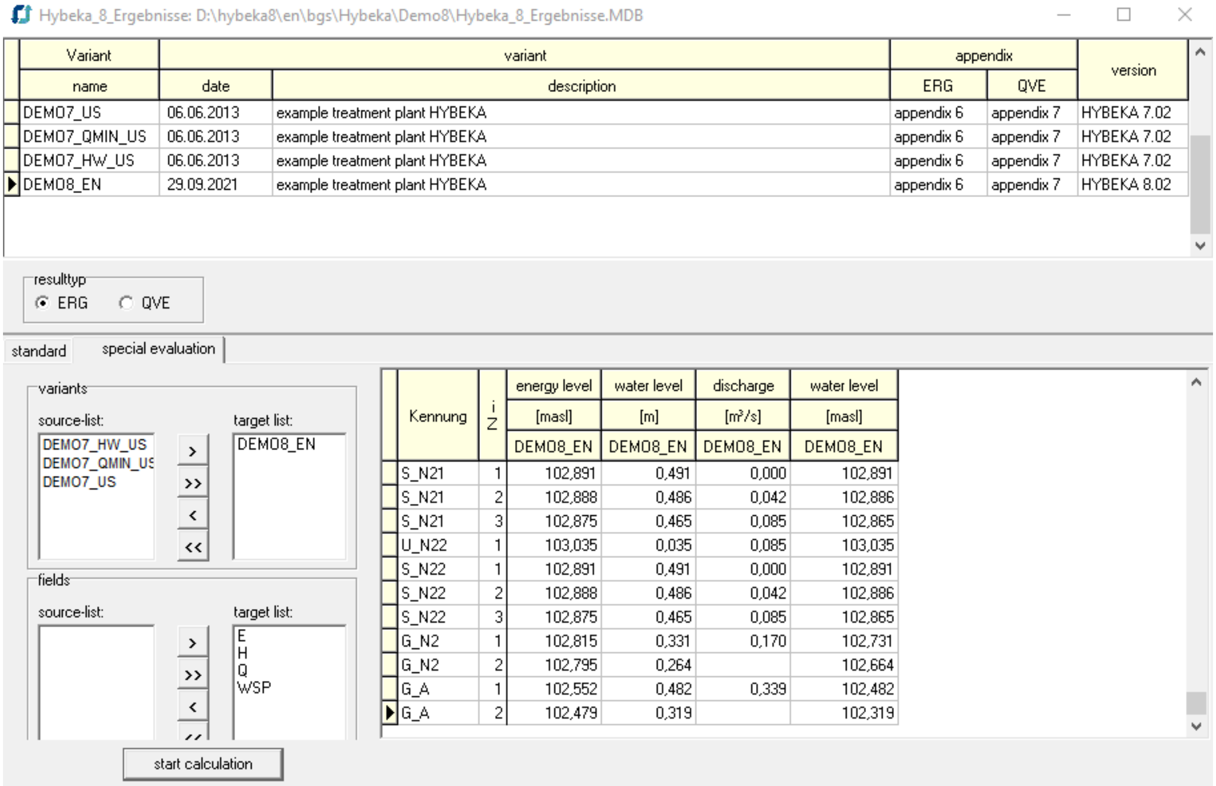


Program call



BGS WASSER

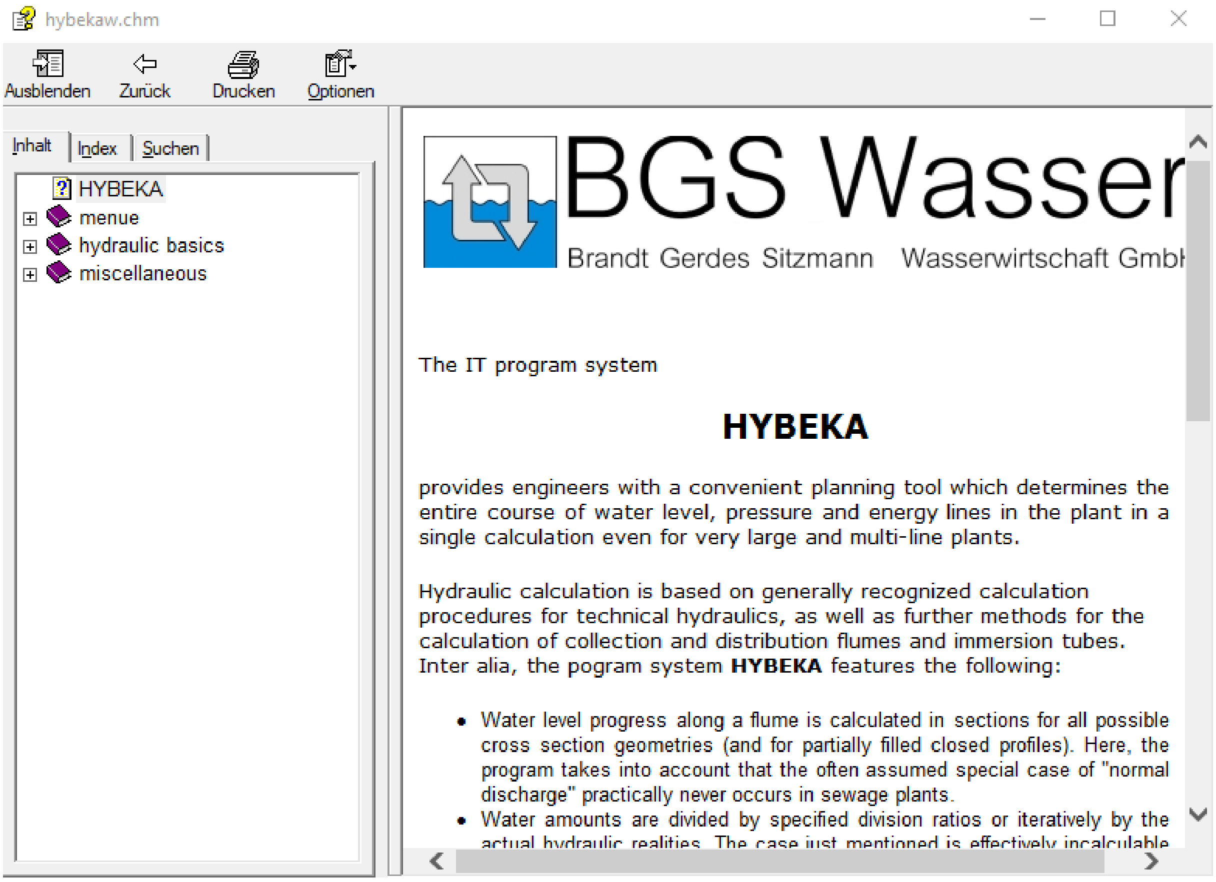
Results database



Variant name	variant date	variant description	appendix ERG	appendix QVE	version
DEMO7_US	06.06.2013	example treatment plant HYBEKA	appendix 6	appendix 7	HYBEKA 7.02
DEMO7_QMIN_US	06.06.2013	example treatment plant HYBEKA	appendix 6	appendix 7	HYBEKA 7.02
DEMO7_HW_US	06.06.2013	example treatment plant HYBEKA	appendix 6	appendix 7	HYBEKA 7.02
DEMO8_EN	29.09.2021	example treatment plant HYBEKA	appendix 6	appendix 7	HYBEKA 8.02

Kennung	i Z	energy level [masl] DEMO8_EN	water level [m] DEMO8_EN	discharge [m³/s] DEMO8_EN	water level [masl] DEMO8_EN
S_N21	1	102,891	0,491	0,000	102,891
S_N21	2	102,888	0,486	0,042	102,886
S_N21	3	102,875	0,465	0,085	102,865
U_N22	1	103,035	0,035	0,085	103,035
S_N22	1	102,891	0,491	0,000	102,891
S_N22	2	102,888	0,486	0,042	102,886
S_N22	3	102,875	0,465	0,085	102,865
G_N2	1	102,815	0,331	0,170	102,731
G_N2	2	102,795	0,264		102,664
G_A	1	102,552	0,482	0,339	102,482
G_A	2	102,479	0,319		102,319

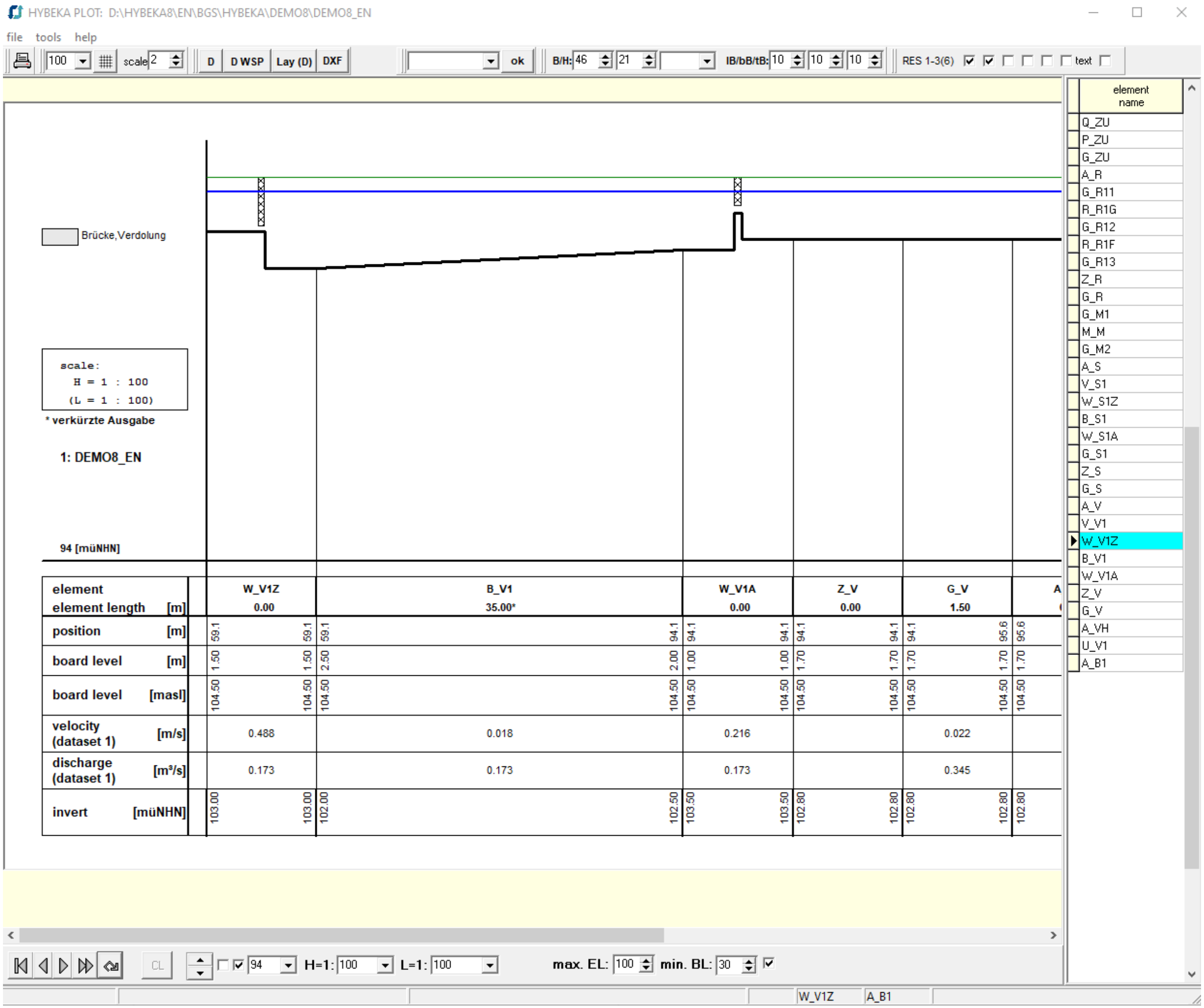
Help



6.2 Graphical presentation of the longitudinal cross section

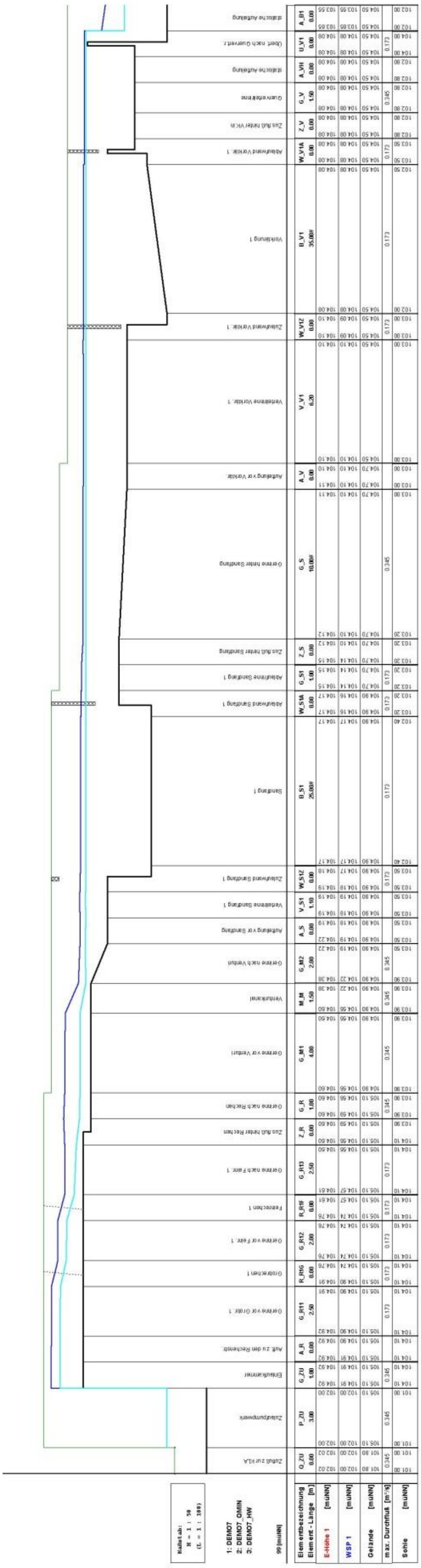
The BGSPlot program graphically displays water levels, as calculated by HYBEKA, in longitudinal cross section on screen. The user then has the following options:

- Visual control of the water levels and energy levels
- Editing the layout on the screen for plotter/printer output
- Export as EMF/WMF/BIT files for import into text-based (word processing) and CAD systems.



The program is structured such that editing the graphical longitudinal cross section on screen is the initial focus (e.g. page size, scale, labeling logs, etc.). This procedure means that only one area of the calculated sewage treatment plant can be dealt with on screen at a time. Browsing the pages and all the results (summary) files is easily accomplished via various functions.

On the following page, a reduced DIN A1 plot for the upper area from inlet to activated sludge unit in the DEMO7 sewage treatment plant is presented.



7 Ordering the program, IT requirements

You can order the IT program HYBEKA and additional programs from:

Brandt·Gerdes·Sitzmann Wasserwirtschaft GmbH
Pfungstädter Straße 20, D-64297 Darmstadt
http://www.bgswasser.de

You then receive the license agreement and if necessary a maintenance and support agreement, with a request to sign. As soon as we have received the signed contracts, we will send you the programs along with the detailed program documentation.

If you have further questions or require further information, please contact Michael Kissel, M.Sc. (Tel.: 06151/9453-32 (switchboard -0), Fax: 06151/9453-80, e-mail: m.kissel@bgswasser.de).

Minimum hardware and software requirements

The following minimum requirements must be met in order to run HYBEKA on your personal computer:

Hardware:

- Minimum 256 MB RAM
- VGA card and 15" VGA monitor
  (resolution at least 800 x 600, small type)
- Disk space for complete installation approx. 10MB

Software:

- Operating systems Windows™ 95, 98, NT, 2000, XP, Vista, 7
- optional: Microsoft ACCESS 2000™ or later

8 Comparing HYBEKA with other programs

To compare HYBEKA with other programs, you should basically consider the very points that are important for sewage treatment plant calculation. For HYBEKA all of the following questions can be answered positively.

- Can the hydraulic element "distribution flume" be calculated?
- Can distribution and collection flumes be impinged by 2 system elements (e.g. collection flumes with overfall on both sides)?
- Can contorted collection flumes be calculated?
- Is a genuine iterative division calculation possible (e.g. for multi-line plants)?
- Can loss coefficients also be predefined, where possible, as flow-dependent for confluences and divisions?
- Can partially filled closed profiles be calculated? Are full and partial fill levels in pipings automatically identified?
- Can divided cross sections be calculated?
- Can flumes optionally be calculated either according to Darcy-Weisbach or Manning-Strickler?
- Are transition losses (most losses occurring at a sewage treatment plant are of this type) automatically calculated (e.g. according to Borda-Carnot), or must at least one loss coefficient be specified respectively?
- Can loss coefficients be taken from a database that the user can expand?
- Is the calculation easily checkable and analyzable through the separated display of all individual losses?
- Is the calculation step size dx automatically adjusted, or must this be provided constantly?
- Can parallel lines be quickly and easily duplicated using the copy functions during data entry?
- Do input and output data have to be output in a "reasonable" format so that they can be attached to an explanatory report (import into word processing)?
- Is it possible to perform section-specific calculations and output selective results?
- Can a large sewage treatment plant (e.g. of more than 500 elements) be calculated?
- Can a large sewage treatment plant be represented and calculated by individual assemblies?
- Does the plot program allow "reasonable" editing on the screen (can the numbers still be read), or can only a plot preview be used?