WBalMo 4.0

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by DHI-WASY

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DHI-WASY *Software*

Interactive simulation system for planning and management of river systems

Introduction

This manual describes not only the **WBalMo** management model, but also its implementation in the current version 4.0. As in most programs, the working steps in **WBalMo** can be taken in various ways; the present help focuses on the most important functions.

New in version 4.0:

General program features:

- **WBalMo** version 4.0 runs as a standalone program and not as an ESRI-ArcView extension, as in earlier versions.

- This is associated with a change in file format for all data: instead of various ESRI shape and dBASE files, a model is now saved as a binary or an XML file.

- An import filter is in place now for **WBalMo** models versions 1.0 (ArcGRM), 2.2, and 3.1.

- A FORTRAN compiler is no longer necessary to execute registry terms and DYN elements. Registry terms are now compiled and made available using .NETspecific methods. DYN elements need to be provided in a compiled form of .DLL files now and the accompanying functions are integrated via **WBalMo** user interface.

Model and data:

- Renamed: **Variant** is now called **Model**

- Renamed and separated: **Simulation sub area i**s now called **Sub area discharge**, or else **Universal time series** (as a new data type) to illustrate the separation between discharge time series and, e.g., meteorological time series

- **Time series** concept: the periods concept for model data was replaced by a time series concept (tuple: point in time, value)

- Time series concept: merging of **C and CC field** as an application of the new time series concept

- Time series concept: **Model data** can be saved in steps of months or weeks

- Time series concept: **Simulation** can be performed in steps of months or weeks

- **Reservoir management**: more than one AEND element can be allocated to a reservoir

- **Metadata**: all model data and registrations can be commented on and model data can be classified using a shortname

- **Registration Type 5**: percentile of a system´s status with a potentially limiting condition, counterpart to **Registration Type 1**

- Registration: All result files are saved as **XML** databases.

Extended modeling:

- Due to restructuring of the technology for registrations and integration of DYN elements, the **variable identifiers**, as well as their accessing procedures, were changed. **OpenMI** (Open Modeling Interface): **WBalMo** features a configurable OpenMI interface, e.g. for coupling with a water quality model.

- **Tracker**: this tool functions as a "magnifier" for individual time steps thus enables a closer inspection of specific effects in the model.

Due to the comprehensive redesign of the software, virtually its entire **handling** has changed. Some items should be highlighted:

- Models can be constructed with and **without** using a **System sketch**.

- Tools to **Search** and **Mark** (set a bookmark at a model object) are available. Connected model objects can be viewed with a special tool.

- Most **lists** serve information as well as navigation purposes (e.g. ranking, search and error lists).

- The **Windows** clipboard was made available for **WBalMo** 4.0. Using the clipboard, it is possible to edit model objects or parts. Additionally, a **clipboard manager** is available to collects the clipboard contents and to makes them useable.

- A **Data check** is no longer performed each time data are entered, but is actively initiated by the user now.

Basis of the Management Model

Time Basis

The program system **WBalMo** serves to reproduce the processes of water yield and water uses either within a balance period or a balance year.

The term balance **Period** usually describes a future time span divided into equal length consisting of several years. Conditions for natural water yield and water demand may change from one period to another. In mining areas, for example, runoff regimes can change due to shifting catchment boundaries, and expected development of future water demands or non-stationary afflux periods can be precisely arranged for the commissioning of new reservoirs. A balance year, representing a special case of balance period, is used when a river basin is to be studied under the conditions of a particular calendar year.

The balance period or balance year is sufficiently often simulated with various stochastically generated water yields. This way, accurate results concerning the effectiveness of the water system can be produced. The sequential reproduction of a balance period by the week or month is called a realization.

Examples

- Balance period between 2003 and 2032, divided into 6 periods of 5-years-long segments each

    - **WBalMo** carries out a preset number ANZR of realizations with ANZP= 6 periods. Each balance period contains LP = 5 years with 12 months. 100 realizations are usually sufficient.

    - A realization has the following time structure:
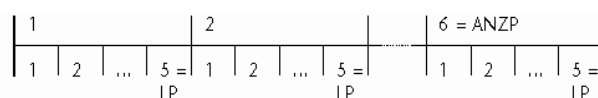
- Balance year 2010

    - The river basin is reproduced under the conditions of the year 2010 (by month), e.g. 1.000 times.

In the **WBalMo** program system, you can choose between **simulation time steps** on a weekly or monthly basis. It is assumed that all operations interfering with the discharge processes in the river basin, such as water utilization or reservoir releases, will become fully effective across the entire river basin during the particular month of interest. Therefore flow times and highly non-stationary discharge phases are not generally accounted for.

If you do wish to consider **flow times** and highly non-stationary drainage phases in very large river basins or during flood periods when modeling, you have two options:

- to integrate corresponding models (e.g. hydraulic models, rainfall-runoff models) using so-called DYN elements or

- to account for the flow time.

The program defines a month as follows:

$$\frac{365\ days}{12} = 2.628 * 10^6\ s$$.

A week in **WBalMo** is based on the following settings:

- Every model year begins on January 1st.

- Every year is consisted of 52 weeks.

- In the case of a leap year, the 9th week contains 8 days.

- The 52nd week contains 8 days.

Balance

WBalMo solves water management problems based on a **simulation model**. This means that natural water yields and consumer demands for water allocation – under the consideration of reservoirs – are set off and balanced against each other. Balancing is performed specific to location in a sufficient number of simulation steps of months or weeks throughout the balance time period or the balance year. It includes the registration of a number of relevant events, enabling the calculation of water supply reliabilities as well as simple statistic features and extreme values by statistical analysis after the simulation is completed.

Construction of a **WBalMo** for a river basin starts with the representation of its water management system, either in an abstract form or as a system sketch. The following model elements need to be specified:

- the relevant **River network** with balance profiles (BP), to enable location-specific positioning of the water management objects,

- boundaries of the **Sub area discharges** to allocate natural water yields,

- water **Users** with all corresponding points of withdrawal and return at the defined BPs,

- **Reservoirs**
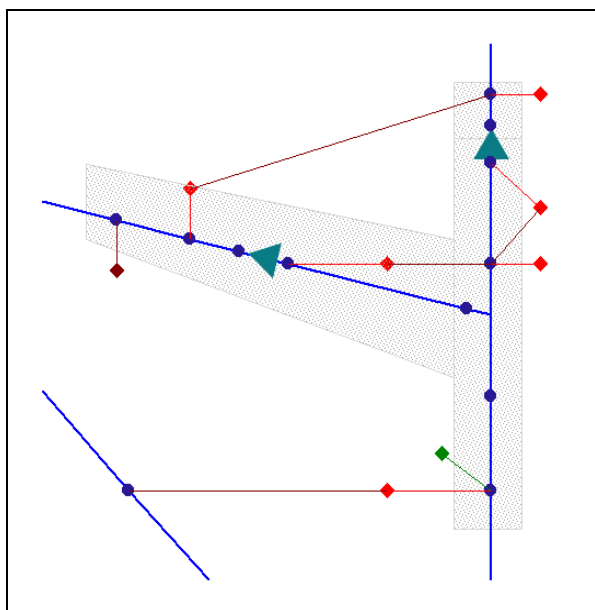
Scheme of a river basin

Application of **WBalMo** further requires that a series of average monthly natural yields exist for all sub area discharges the river system has been subdivided into. This can either be the records of discharges adjusted for utilization, or stochastically generated discharges based on the records. The latter case is also referred to as an application of the Monte Carlo technique for water management problems and should be preferred.

The processes of utilization are modeled by users, reservoir releases (release elements and AEND elements), and so-called dynamic elements (DYN elements) in **WBalMo**. Allof these model elements receive a **Rank**. A user´s rank represents his importance in the system of all users throughout the river basin. Ranks of release elements (AB) and DYN elements serve to classify them in the consumer hierarchy.

Balancing is performed gradually throughout a month based on the drainage scheme outlined in the following figure:
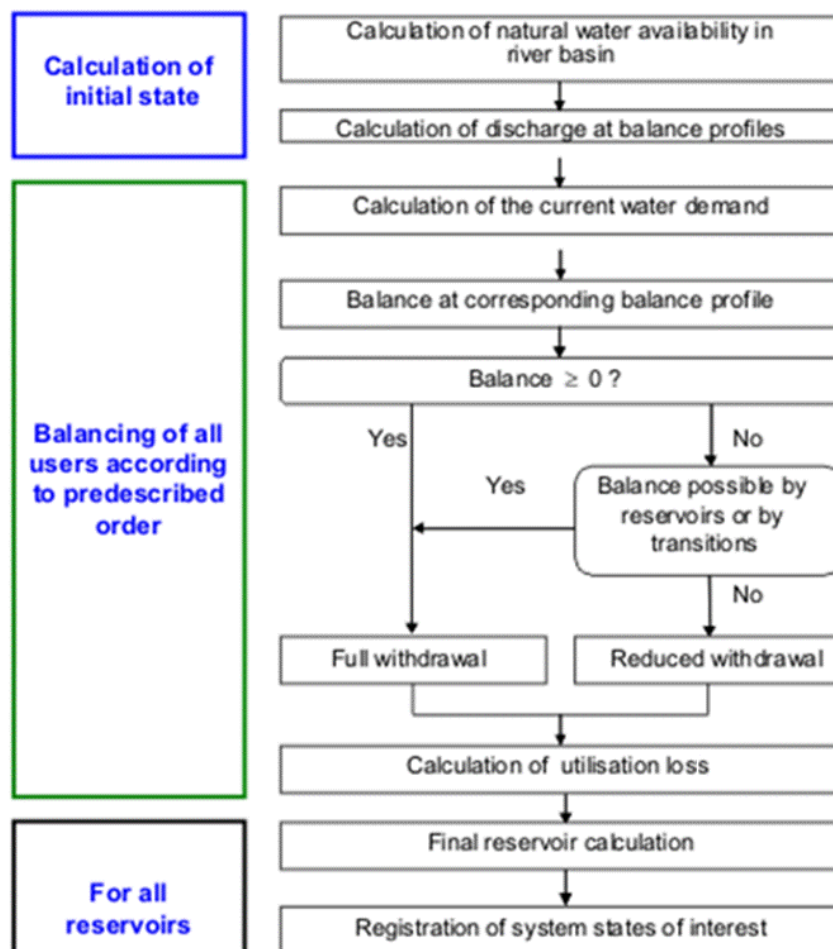
Flow chart of balancing in a time step

Reproducing Natural Water Yield

Relevant monthly or weekly discharges are generally taken from the discharge files for every sub area. Sub area discharges are split across adjacent balance profiles in this sub area according to their simulation shares, and finally added to the flow direction. The outcome is the natural discharge situation in the river basin.

Balancing (Imprinting) Water Uses

In the beginning of balancing, all users, release elements, AEND and DYN elements are filed into a list in ascending order of their pre-described ranks. The ranking list is then processed successively, starting with the smallest rank. If the water supplies are threatened, users can be supported by backup reservoir releases.

Processing the ranking list as described above will gradually transfer the river system´s natural discharge state into the **final managed state** for the month in question. Only this final state will be relevant to water resources management. The **WBalMo** principle of immediately modifying the discharge at all of the concerned balance profiles in the flow direction following withdrawals, return flows, or reservoir releases allows for a balancing the water users as outlined above.

Registration of the relevant state variables, such as discharges at selected balance profiles, current water withdrawals by particular users, or storage levels of individual reservoirs takes place only at the end of the monthly balance.

Model Elements

River and Balance Profile

The model structure is defined by the relevant **Rivers** in the study area.

Balance **Profiles** along the rivers serve to split the total yield into **Sub area discharges** and to position the locations of water **utilization** in the river basin. Reservoirs should always be positioned between two balance profiles. Additionally, you can make **Registrations** of the discharges at these profiles.

Sub Area Discharge

To establish water yields, the river basin is divided into so-called **sub area discharges**. Corresponding series of recorded or simulated discharges adjusted for user influences are needed for all sub area discharges. You can define the time units by weeks or months. These discharges need to be saved in individual files and in a chronological order based on calendar year.

The discharge series required for **WBalMo** usually comes from observed mean weekly or monthly discharges. They need to be adjusted for the following **management and utilization effects**:

- Water losses due to water utilization in municipalities, industrial and agricultural settings
- Temporal reallocation of natural yield by reservoir management
- Spatial reallocation of resources by water transfer

The resulting series can be directly passed onto **WBalMo**, where the maximum simulation length is limited by the length of the recorded series. The lack of accuracy of the results usually implied by this can be avoided by using sufficiently long artificially generated discharge series, which makes it necessary to set up a stochastic simulation model. For the working steps required, the **SIKO** program is used for mathematical-statistical analysis of the adjusted discharge series and to calculate simulation correlations, while the **SIMO** program is responsible for generating series of any lengths [**SIKO/SIMO** programs for stochastic simulation, **WASY***Software*, 2000].

If it is not feasible to adjust gauged discharge series, e.g. owing to mining influences, it becomes necessary to use rainfall-runoff (RR) models and stochastic simulations of meteorological factors, such as precipitation and potential evaporation. For lowland areas and mining regions, the RR model **EGMOD**, which also runs on a monthly basis has proved useful. As an alternative to pre-generated discharge series, it is possible to implement or activate an RR model in a DYN pre-element.

Because partitioning of a river basin usually turns out rougher if done by sub area discharges instead of given balance profiles, sub area discharges generally have to be allocated to sub areas according to their **simulation shares**.

- Sub area discharges between balance profiles and their respective upstream profiles are determined by their shares. Thus with river mouths, several upstream profiles exist.

- Negative shares are permitted. They are needed to establish sub area discharges from differences between gauge values.

- Profiles without proprietary discharges have no share in the sub area discharge (relative share equals zero).

Natural initial discharges are produced in **WBalMo** through successive addition of the sub area discharges at all balance profiles in the flow direction at the beginning of each simulation month.

Universal Time Series

Universal time series can be compared to sub area discharges, except that they do not contain discharges from sub basins but other time series data, e.g. climate data, such as temperature, humidity, etc.

Universal time series data are provided to DYN elements and thus registration terms always entered into the simulation directly. Below are examples of universal some time series:

- Integration of an RR model

- Implementation of an evaporation function for a reservoir based on air temperature and wind velocity.

User

Demands for water utilization in a river basin are captured by defining its **Users**, indicating their locations and profiles of withdrawal and/or return, as well as their monthly withdrawal demands (E), corresponding return flows (R) and ranks (Z) describing this user´s importance inside the overall system. If the factors E, R and Z are equal for all months of the calendars, it is sufficient to enter an annual value, otherwise an annual variation consisting of 12 monthly values can be defined for the according factor. In **WBalMo** the balancing of users is carried out in an ascending ranking order, which means a lower rank equals preferential water provision. If deficits arise, the ratios of reduced to demanded withdrawals would equal those of reduced to planned return flows.

Three types of users exist:

- Users with withdrawal and return flow at one balance profile or at two different profiles

- Users with return flow at one balance profile

- Users with minimum discharge at one profile.

Several users may be located at one profile, and are balanced according to their ranks. Ranking orders for these users in this case must coincide with their positions in the flow direction.

User demands are defined in the form of several users, if

- Overall demand can be divided into partial demand values with different ranks (different importance of individual demands), or

- Proportion between actual withdrawal and actual return flow does not correspond to reality in the case of deficit.

When summarizing a balance sub area´s utilization demands in a profile, please consider that values of withdrawal and return flow quantities generally do not add up.

Only positive values are permissible for both input variables withdrawal demand E and return volume R, so that $0 \leq R \leq E$ applies.

- As an exception, the combination E = 0 and R > 0 is permitted and is balanced the same as for the user type. Combinations of this type can occur in individual months, particularly when annual variations are entered, e.g. with fish pond management (months with either withdrawal or return flows only).

Reservoir

In **WBalMo**, the **Active capacity** IBR or R3 of a **Reservoir** is the only item for reservoir management that is permitted to vary in size over the month (active capacity NG). The maximum active capacity in a year is called Storage capacity SK.

In agreement with practical reservoir management experience, the integration of reservoirs in a river basin is founded on three premises in **WBalMo**:

- A **reservoir** or **grouped reservoirs** preferentially or exclusively serve to provide water to a user or a specific group of users.

- A reservoir or grouped reservoirs usually provides just the amount of water necessary to cover all water demands for affiliated users or groups of users (demand-oriented reservoir management). Exceptions will occur in dry periods in the form of **deficits** (low storage level), and in wet periods in the form of **surpluses** (reservoir overflows).

- However, a **Mandatory release** can be set which has to be met whenever possible.

This concept is realized in **WBalMo** after defining a reservoir by specifying its size, initial filling and, if applicable, its combination status by two predefinitions:

- To define so-called **Release elements** which determine the water volume in the reservoir available to users.

- To determine (implicitly) the group of users to be supplied directly from the reservoir, exclusively by applying **ranks for the AB- and AEND elements**.

Since the balancing process in **WBalMo** is performed successively according to the ranking list order, availability of the reservoir volume will change when it encounters an **AB element**. Availability increases if the users further down in the ranking list are to preferentially supplied from this reservoir, and decreases otherwise. Depending on the reservoir storage level, an increase or a decrease of availability is in effect either from immediate release from the reservoir or from the reduction of previously completed releases, naturally without disadvantaging users of lower ranks that have already been balanced.

On the other hand, operation of the respective reservoir is terminated in a particular month by working off the **AEND element**. Users of higher ranks following the AEND element are thus excluded from the direct preferential supply from this reservoir.

A release element makes a defined maximum quantity of water available to the group of users to be supplied. This is carried out inside the program by reducing the reservoir volume (purely by calculation) to a target minimum **Storage level**, which is set by a limit value G and/ or a coefficient BETA. While the AEND element is processed after the affected users have been balanced, the share of this potentially available minimum water quantity is established which was actually required by the users, while the unused water, if any, is "re-calculated" into the reservoir. As a result, the reservoir´s actual volume and the storage releases are obtained.

If a reservoir is to supply various user groups with different availabilities, you need to define several AB elements. The ranks of these release elements must be higher than those of the respective user groups.

The above concept for reservoir management is also realized stepwise. Only the final state after processing the entire ranking list is relevant in practice.

AEND Element

Often a water quantity for a particular user group is released suddenly from the reservoir in question to its lower reaches by an **AB element** which exceeds the actual required volume. By this, calculating a required storage release for each individual user in the model was avoided. In order to reproduce demand-oriented management in **WBalMo**, however, a final calculation has to be done for each reservoir every month which "calculates back" into the reservoir the water not claimed by users. This is achieved by ranked release elements (**AEND elements**) which enable two types of final calculation, and, thus, reservoir control: **individual** and **combined reservoir management**.

Individual Reservoir Regulation

If an **individual reservoir regulation AEND element** is activated while the ranking list is gradually processed, the quantity of unclaimed downstream water is established. Under the consideration of the reservoir´s storage level, the current reservoir storage volume is increased by this quantity, and flow volume is reduced accordingly downstream. The order of this final calculation, and thus the order of reservoir utilization, can be specified using AEND element ranks: a low AEND element rank indicates priority for the replenishment of the reservoir, which in the end corresponds to reduced utilization. A higher rank, on the other hand, leads to higher demands on the considered reservoir. This way a smaller AEND element rank describes a higher degree of reservoir preservation.

Grouped Reservoir Management

If your goal is the efficient utilization of a group of reservoirs in a river basin, you can use the **grouped reservoir management** implemented in **WBalMo**. The current free storage capacity of each combined reservoir, that is the volume between the current reservoir **Storage level** SI (adjusted by the last release element) and the **Active reservoir capacity** NG, is split into two scopes by the **Limit value** GR. Replenishment calculation is then performed in two steps, first up to the Target storage level GR, then up to the **Active reservoir capacity** NG. The approximately even, proportional utilization of all grouped reservoirs is achieved by subdividing both capacities of all reservoirs in IGR and ING into equal-sized "slices". Surplus reservoir releases are distributed between the reservoirs of an combination by the algorithm such that the 1st slices of all reservoirs are replenished first, followed by the 2nd and 3rd slices, and so on. Dependent on the reservoir locations and utilization conditions in the individual river courses, maximum possible proportionality for reservoir utilization is achieved. A standard value of 10 appears to be sufficient number of slices. No other elements with ranks may be arranged between the ranks of AEND elements belonging to a group.

Mandatory Release

If a **Mandatory release** were to be exacted from a reservoir, e.g. in connection with a Qmin type user, an AEND-Element would also be needed. After the reservoir of interest has been emptied in the beginning of a month´s balancing following the balancing of all its upstream users, this Qmin type user is next to be balanced and the AEND element is to be activated immediately afterward.

After a particular reservoir has been emptied at the start of balancing in the beginning of the month, and after balancing all users upstream from this reservoir, this Qmin user is to be balanced and the AEND element is to be activated immediately afterwards. The desired volume of the mandatory release can be set using the user´s E values, or by using a DYN element.

The use of mandatory release results in a strict separation of the balances of all the reservoir´s upstream users from those downstream. In this case, preferential water supply to the downstream users is not feasible.

Release Element

Availabilities for specific users of reservoir volumes and quantities of reservoir releases are adjusted in **WBalMo** by applying ranked **Release elements** (AB elements). For a release

element, this adjustment is performed by gradually working off the ranking list for all users, as well as release, AEND, and DYN elements. This setting occurs that in the case an AB element is encountered and remains valid for all users subsequent in the ranking list, until the availability is changed either by another AB element of the same reservoir, or calculation of the current month is concluded by the reservoir´s AEND element. Several AB elements may be defined for each reservoir.

In the beginning of a time step, standard availability for all reservoirs is regarded as Outflow = Inflow, i.e. the reservoir storage level SI = SIA remains unchanged.

Availability is set based on the two corrective variables G and BETA, and calculates the limit value GW.

$$GW = MAX (G, BETA \bullet SIA)$$

This affects the following operations:

- Increase in availability if SI > GW (GW = minimum storage level) with

  o Decrease in reservoir storage level to SI = GW,

  o raising of reservoir release to SI – GW, increasing the discharge rate at all downstream profiles by this release.

- Decrease in availability if SI < GW (GW = maximum storage level) with

  o calculation of the discharge rate portion H in the downstream reaches that has not been balanced (so-called "free rate"),

  o raising of reservoir storage level to SI = MIN (GW, NG, SIA, SI + H) for reserve purposes,

  o corresponding reduction of reservoir releases and of discharge in the downstream reaches.

This makes clear, that

- the factor GW can function as a minimum or maximum level respectively, depending on the current reservoir storage level SI, which is just set in the course of balancing,

- it is not possible to supplement or replenish a reservoir to a degree exceeding the current reservoir level SIA at the beginning of a month if it is to the disadvantage of user satisfaction in the considered month,

- a desired lowering Δ of the current reservoir storage level SI is also not achievable only by an AB element (only possible in combination with DYN elements).

Although the regulation of releases by AB elements has the advantage of enabling demand-oriented and thereby economical reservoir management, it usually takes a great deal of

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considerations and, most of the time, the implementation of DYN elements to translate existing management plans into the "language" of **WBalMo**. Inversely, it is generally difficult to translate a **WBalMo** reservoir control into operational practice unless **WBalMo**´s entire balancing algorithm is integrated into the operational control model for a river basin, and "fed" with the actual system state (current gauge data, reservoir volumes, user withdrawals and return flows. On reservoir releases set in advance or values calculated by functions can be easily reproduced using the mandatory release.

DYN Element

Particular river basin management rules, registration requirements or other necessary operations cannot be formulated using **WBalMo**´s standard elements. However, they can still be incorporated by defining "dynamic elements". Performance of the standard algorithm is interrupted by **DYN elements** in order to process a given individual user algorithm. These algorithms generally refer to relevant values of the system´s state variables and other program variables. By the specification of a rank, the dynamic element can be filed into the ranking list of all user and storage elements, and thus at that instance is determined when the standard algorithm is interrupted.

DYN elements can be classified as follows:

- One-time execution at the beginning of a simulation run.
- Execution prior to imprinting the natural discharge.
- Execution inside the management processes.
- One-time execution at the end of a simulation run.

Here are some examples for the application of DYN elements:

- Setting state variables at the beginning of a realization, a period or a year.
- Calculating evaporation losses from reservoirs depending on current reservoir storage level and simulated potential evaporation.
- Calculating variable transfer quantities depending on the discharge rate at the profile of withdrawal.
- Registration of hydrographs of relevant system states in individually defined dry periods.
- Integration of models for water balance calculations for flood management with time steps < 1 month, to calculate dependencies between groundwater and reservoir storage level, or to incorporate water quality criteria into management.
- Output of selected **WBalMo** state variables or values derived from them into additional files.

Numerical Parameters

Numerical Parameters serve to transfer data to or between DYN elements and to registrations. Examples:

- Recording of water levels and evaporation losses in reservoirs for registration and use in other DYN elements, respectively.

- Summation of different factors (e.g., sum of releases from several reservoirs for a specific use) for registration purposes.

- Marking storage levels of reservoirs that trigger the application of special regulations.

String Parameters

String parameters are alphanumeric values to be used in DYN elements.

Examples:

- File name and menu path name

- Formatting instructions.

Ranking List

To enable the **WBalMo** balance algorithm, the **WBalMo** elements "User", "Release element" and "DYN element" need to be assigned a **Rank**. Registrations Type 4 also possesses ranks. A rank is a positive decimal number and may feature a yearly or weekly variation. It serves to sort each model element into the overall system of all existing data; and apart from that has no further purpose. A smaller rank number translates to higher priority of water supply. Ranking sorts the users into a ranking list in ascending order corresponding to their importance (e.g. drinking water supply before agricultural irrigation). As this ranking list is used in each simulation time step according to the balancing algorithm, starting with the smallest rank, the "more important" users are first supplied with water.

However, the ranks do not always reflect the level of importance of the users. If, for example, a calculation were planned on the principle of "upstream before downstream users", the users would be assigned rank numbers rising in the flow direction of the particular river.

Example for preferential water supply to industrial users

Element	Distance from river mouth [km]	Name	Rank	Effect
...	...	...	...	...
N	8.9	Power plant	24	Withdrawal by PP
N	4.1	Industrial facility	30	Restricted withdrawal, if so
N	11.0	Irrigation	31.5	Possibility of withdrawal questionable
...		...	...	...

The objective of assigning ranks to release elements of the reservoirs (AB elements, AEND elements) is to reserve a particular portion of the current reservoir volume for a single user or a group of users. This way, important utilizations can be supported by reservoir releases during dry periods, while other utilizations are already reduced or interrupted. Therefore, the rank of an **AB element with a (lower) minimum storage level** must be fixed to be lower than the ranks of the priority users. Less important users can be excluded from supplies by setting another AB element with a (higher) minimum storage level and a lower rank than those of the users that are subsequently balanced.

Replenishment of the reservoirs is likewise controlled by the ranks assigned to the release elements. If a reservoir is subject to higher demand than another reservoir due to a larger number of connected users, its **AB elements with (higher) minimum storage level** and its AEND element must be given higher ranks than those of the competing reservoir. As a result, it is replenished (in the sense of balance) after the other reservoir has been filled, so that, as the case may be, there will occasionally be insufficient to no more water available in the river basin for replenishment.

Example for differential supply from a reservoir

Element	Distance from river mouth [km]	Name	Rank	Effect
...	...	...	...	...
AB[1.2]	8.9	Reservoir 1 with a capacity of 100 hm³	24.0	High release through large drawdown to 10 hm³: share exceeding 10 hm³ is available
N	5.0	Power plant	24.5	Full withdrawal with generally high reliability
AB[1.3]	8.9	Reservoir 1 with a capacity of 100 hm³	30.0	Release restricted by new minimum storage level of 80 hm³: only share exceeding 80 hm³ available
N	7.0	Irrigation	31.5	Withdrawal often restricted by low reservoir supplies
...		...	...	...

If a preset release volume is to be ensured at all times, this case is handled in **WBalMo** by installing a "**Mandatory release**".

Example for standard release volume from a reservoir

Element	Distance from river mouth [km]	Name	Rank	Effect
...	...	...	...	...
AB[1.1]	8.9	Reservoir 1	1.0	Complete emptying of Reservoir 1 (minimum storage level = 0)
...	>8.9	Balance of all users upstream Reservoir 1	1.0 < Z < 24.9	
N	8.9	Balance of a user of the Qmin type	24.9	Mandatory release is "fixed" (exceptions: reservoir is empty or overflowing)
AEND[1]	8.9	Final calculation for Reservoir 1	25.0	Maximum replenishment of Reservoir 1 under consideration of inflow and mandatory release
	25.0	Balance of all users downstream Reservoir 1	Z > 25.1	

If specific requirements in the application area, such as the need to incorporate discharge-dependent water transfers or particular reservoir regulations, make it necessary to interfere with the algorithm, **DYN elements**, which are also ranked, are available. Here, the ranks serve to precisely sort their customized algorithms into the sequence of **WBalMo** standard algorithms. For example, if a DYN element contains the calculation for a variable transfer quantity, it needs to be assigned a rank smaller than that of the respective transfer user. The same procedure is applied when the minimum storage level of a reservoir is calculated in a DYN element. In this case the rank of the DYN element must be smaller than that of the AB element.

Example of rank-based classification of a DYN element

Element	Distance from river mouth [km]	Denotation	Rank	Effect
...	...	...	...	...
DYN	-	Calculation of maximum possible transfer volume ÜL as a function of discharge at km 9.5 and the capacity of 2 m³/s	24	
N	9.5 (main river)	Transfer from km 9.5 to tributary km 2.2	30	Transfer ÜL to tributary km 2.2
N	1.5 (tributary)	Irrigation	31.5	Withdrawal for irrigation at tributary km 1.5

Summary of Effects from Ranks

At the beginning of a monthly balance, all users, AB, AEND and DYN elements are sorted into a ranking list in an ascending order. The ranking list is then processed successively, starting with the smallest rank:

If the list element is a **user**, his current withdrawal demand is attempted to be covered from the discharge at the withdrawal profile. Thereby the previously balanced withdrawals of users from the same and from downstream balance profiles are taken into account. If the

user is to be supported by storage releases or transfers, the corresponding release elements or transfers need to be activated before (hence, their respective ranks must be smaller). The current possible withdrawal amount by the user (< demand) and the return flows are fixed, and cause changes in the discharge at the corresponding balance profile and all downstream balance profiles.

- A release element refers to a particular reservoir and changes the **availability** of the water stored in it. Availability (release) is increased where it is intended to support the subsequent users in the ranking list, and otherwise reduced (example: a power plant is supported by reservoir releases, while an irrigation facility receives no reservoir allowance). Reservoir releases change the discharge at all downstream balance profiles.

- If the list element is a DYN element, its instructions are followed. This usually applies to **usage processes** which cannot be performed by **WBalMo** standard algorithms (example: calculation of evaporation from a reservoir as a function of current reservoir volume, or discharge-dependent transfers).

- An AEND element carries out a **final reservoir calculation**. Taking into account the previously balanced withdrawals by downstream users, the maximum possible quantity from inflow is used to replenish the reservoir. Water quantities exceeding the active reservoir storage capacity are passed on as overflow (over the upper operation volume margin) to the downstream reaches. The respective reservoir is no longer responsible for more users in the current time step.

Because **WBalMo** immediately carries out modifications at all concerned profiles and state variables after system states were changed, the **natural discharge state** of the river basin is gradually transformed into the **final managed state** by working off the ranking list. Only this final state would be observed in reality, if the river were managed according to the rules integrated into **WBalMo**. This final state is generally only relevant for registrations.

Registration

Any simulation of water utilization processes in a river basin requires **registration** of the simulated system variables in order to evaluate the quality of the management model. Registration includes frequency distributions, statistic numbers and extremes. **WBalMo** registers both state variables and event durations. Five types of registration tables exist for this.

Registration Type 1

Registration Type 1 is the registration of **state variables** (numeric values); the output consists of a table containing percentage exceeding frequencies or, in other words, reliabilities of values from a given registration scale.

Examples Registration Type 1

State variable	Registration term	Unit	Sorting scale
Storage level of Reservoir 3 (active storage: 25 hm³)	VarPublic.StorageCurrent[3]	hm³	2.5, 5.0, 7.5, 10.0, 12.5 ... 25.0
Discharge at Profile 27	VarPublic.Discharge[27]	m³/s	0.5, 1.0, 1.5, 2.0, ... , 10.0
Relative satisfaction of demands by User 8.4	100*VarPublic.WithdrawalBalanced[8.4]/VarPublic.Withdrawal[8.4]	%	50, 60, 70, 80, 90, 100
Evaporation loss of Reservoir 3	VarPublic.ConstNumber[13]	hm³	0.1, 0.2, 0.3, ..., 1.0

Registration Type 2

Registration tables Type 2 serves to record **event durations**; the output is a table containing relative frequencies for the occurrence of events over fixed duration, with the events starting in any of the 12 calendar months.

Examples Registration Type 2

Event	Registration Term	Sorting scale [months]
Discharge falls below 5 m³/s at Profile 8	VarPublic.Discharge[8] < 5.0*2.628 *)	1, 2, 3, 4, 5, 6
Current storage level exceeds 22.5 hm³ in Reservoir 3	VarPublic.StorageCurrent[3] > 22.5	1, 2, 3, ... , 12

*) Factor 2.628 serves to convert [m³/s] into the internal **WBalMo** unit [hm³/month]

Registration Type 3

Registrations Type 3 is the registration of **means, standard deviations, minima** and **maxima** of **state variables**. These variables are calculated separately for each month and calendar year, respectively. They are given as follows:

- in case of a **WBalMo** based on a balance year, for this particular year,
- in case of a **WBalMo** based on a balance period (e.g. 2003-2052),
  - for each individual year of the period (e.g. 2010, 2020),
  - for each period (e.g. 2003-2007, 2008-2012, 2013-2017) or
  - any optional term (e.g. 2003-2010).

Examples for registration terms: refer to Registration Type 1.

Registration Type 4

Registrations Type 4 allows the output of **state variables** as a **continual time series** for each simulation step. Several variables can be consolidated into one block in every registration. By assigning a **rank**, the registration can be sorted into the ranking list. Thus, model states can be displayed while the ranking list is run through, and subsequently evaluated. The output can be additionally filtered using a restricting logical term.

Examples:

- Output of a sequence of state variable at the end of a simulation month.
- Output of state variables before and after a particular reservoir release.
- Limitation of output to particular years.

Registration Type 5

Registration Type 5 is much like a counterpart to **Registration Type 1**: while in Type 1, you register state variables and the result is a table of percentage exceeding frequencies, in Type 5 a percentile is set. The output is the value of a term, that is, a **system state** such as demand or reservoir storage level reached with this particular **Frequency.** Using a logical term, the total number of processed values can be restricted.

Flow Time

In large investigation areas with accordingly relevant flow distances, it can become necessary to account for the influence of **Flow time**. In doing so, the flow time must be considered not only when the natural discharge state is established in the beginning of a balance calculation, but also including all management effects on downstream balance profiles.

Although flow times in natural systems always depend on discharge and seasons, it still makes sense to consider only their dependency on location, for the following reasons:

- With respect to flow times determined by flow distances, the dependency on discharge and seasons represents only a corrective variable.
- It demands considerable effort to identify time- and discharge-dependent flow times.

Flow Time Model

As time base for the balance calculation, the month is used which is valid at the closing profile of the study area. Because all processes are synchronized to this month, it is also named **synchronal month**. The basic **WBalMo** assumption of simultaneous balance of discharge and users applies in the synchronal month.

All processes occurring upstream from the closing profile, and thus earlier, are preponed by the corresponding flow time. Thus they are considered in earlier months with respect to the closing profile.

Flow times can be determined in days, and thereby in parts of months. The "simulation month" on model level is thereby not regarded as a point in time, but as a **time interval**. The values effective in the simulation month (input values and results) are means of this interval.

Examples:

- "M4" indicates the month of April, which is the interval [1.4.-30.4.].

- "M4, 33" indicates the interval 0.33 months later, which is approximately [11/04-10/05].

- Input values for flow times from balance profiles to their corresponding closing profiles are entered as decimals.

The above mentioned in principle also applies across **Period** limits. With models covering a balance period, pay attention to the following:

- In the first balance year of every realization, effects from earlier processes must be accounted for. These processes took place before the first period started, that is, in period "zero". In the model, data of the first period are assumed to be valid for the "zero" period.

- If numeric or string parameters are used, mind that the values stored there are not automatically synchronized. If synchronization becomes necessary, it can be done with DYN elements. If input values with a periodic variability are used in registrations, an according DYN element should be set specifically for synchronization.

- Registering of the system states takes place after all balance calculations in the synchronal month have been completed. The registered values, owing to the flow time, are then assigned to a later month. However, the particular processes, including their (local) effects, have actually occurred at an earlier time. The results are obtained only after "backward synchronization" of the registered values.

Data Relevant to Flow Time

When calculating the influence of flow time on discharge processes, the following details should be considered regarding the relevant data:

Balance profile:

- Total flow time up to closing profile.

Sub area discharge:

- Reference profile.

- The profile located farthest downstream in the sub area is suited best to be the reference profile.

- Flow time for the natural discharge process is not further differentiated inside a sub area.

Universal time series:

- Reference profile.

- Data from a universal time series is synchronized during simulation on the basis of the time lag determined by the reference profile.

User:

- Inside the model, the profile of withdrawal (for return flow users: the profile of return flow) is assigned as reference profile.

- For users located at different EP and RP, no flow time is permitted between the profiles.

Reservoir, release element:

- Inside the model, the profile downstream from the reservoir is used as the reference profile.

DYN elements:

- If discharge-dependent or discharge-modifying processes are formulated in DYN elements using time-dependent parameters (numeric and string parameters), these parameters must be synchronized to the relevant balance profile.

Registrations:

- Reference profile.

- The reference profile used depends on the model elements activated by the registration terms.

- Use of variable numeric and string parameters: see above.

- For the input values Q, E, R, NG, GR, G and BETA, the values respectively valid in the synchronal month are calculated by time lag and interpolation.

Regions

Both, sub basin areas and intermediate areas with flow times which are neglected in the model are named **Regions**.

A balance profile for which no flow time is given is assigned the same flow time as its downstream profile. A region is a river basin located between two profiles with flow times.

Decisive features of regions are the option to privilege downstream users in modeling by dealing them higher ranks and thus, advantages in balancing, as well as the option to adjust reservoir releases according to demand.

Variables of all model elements in a region can be combined with each other in a registration term without restrictions.

Limitations in Accounting for Flow Times

In systems with flow time influences, it is generally no longer possible to model random **Ranking orders**. This is because strategies which comprise the priority of downstream users over upstream users are not viable without prediction models. The same goes for advantaging individual usages by reservoir releases. This limitation applies whenever a flow time occurs between upstream user (**User** or **Reservoir**) and downstream user (**User**) that cannot be neglected.

- Yearly variations of ranks are not possible, because synchronization would lead to other, paradoxical ranking lists.

- Registration terms with combinations of variables referring to balance profiles that have flow times between them usually make no sense.

WBalMo Program Frame

System Requirements

- Hardware (minimum): processor 400 MHz, RAM 128 MB, Storage volume 50 MB

- Software: Microsoft Windows- XP, Windows-Vista or Windows- 7; 32 or 64 Bit, Microsoft .NET Framework 2.0

Installation

Starting the Program

Start the program **WBalMo** by double-clicking the **WBalMo** icon.

At the first start or if no valid configuration is accessible, default settings will be applied. These options can be modified if necessary, and saved user-specific as configurations. Registering of the license is also done in the **WBalMo** configuration**.**

Configuring WBalMo

In **Extras | Configuration**, you can specify your favorite settings after logging in. Establishing a user profile gives you the option of e.g. fixing language or other settings that may differ from the standard profile. Items such as history lists which enable you to select **Recent models** can only be made where a user profile exists.

The chosen settings are saved and provided to each individual user by default whenever setting up a new model, if the option **Configuration for current user (...)** on the **General** tab is active. However, to do this as a user, you need administrative privileges. Otherwise some configuring options are greyed out and thus remain inactive.
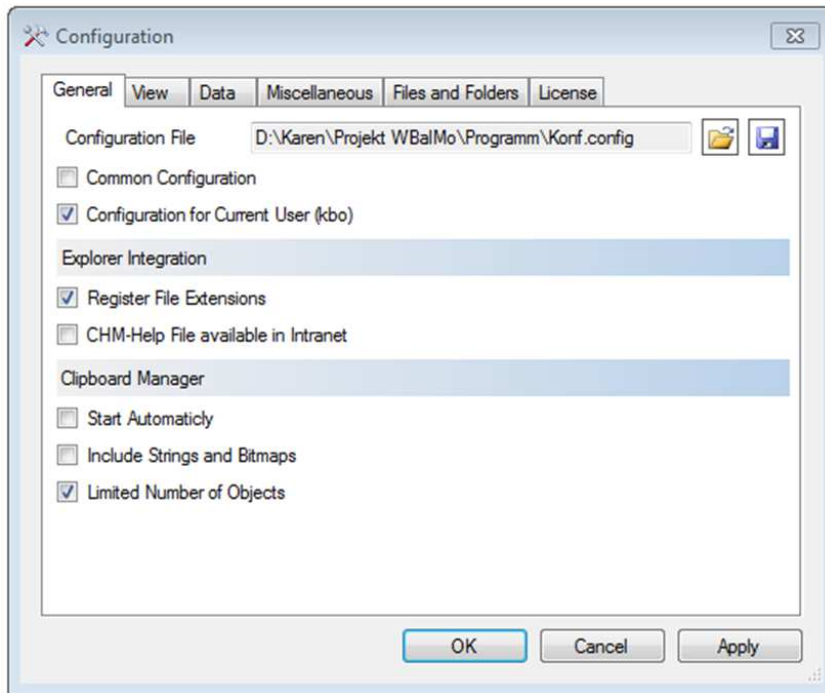
Here is a selection of important settings**:**

- Save **Configuration**, otherwise all settings made here only apply for the current program session (tab General).

- Set the **Language** for the program interface (tab **View**).

- Save window positions: window positions existing at the time the program was closed are restored when **WBalMo** is restarted (tab View).

- **File succession** of previously used models, projects and other files is saved and made available in the according places.

General Suggestions for the User Interface

All functions can be accessed using the menu bar. However, some interactions constitute exceptions in this sense, as they are only accessible directly by popup menus inside the system sketch. The menu bar features the following items:

- File

- Edit

- Project

- Model

- Data

- Sketch

- Extras

- Window

- Help.

Below the menu bar, buttons on both toolbars offer quick access to often used tools:

Buttons on the upper toolbar:

	New model
	Open model
	Save model
	Save all
	Copy
	Paste
	Mark object
	Check
	Model properties
	Sketch settings
	Perform check
	Simulation
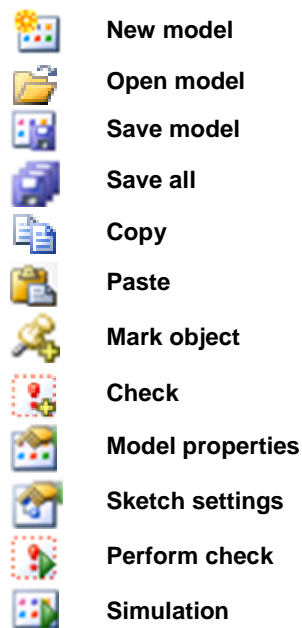
The lower toolbar contains tools connected to the system sketch:

Mark: Draw a rectangle comprising several objects in order to mark them. Select the marking task by right mouse click.

Select the data **Type** you want to work with:

	Rivers
	Balance profile
	Sub area discharge
	Universal time series
	User
	Reservoir

Choose the task for the selected data type from a dropdown list:
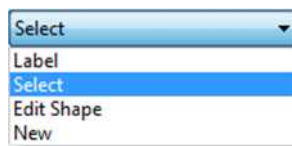
Further tools are available to edit the **Labeling** of the **System sketch** and for **Zoom** functions.

Window manager

The **Window manager** enables you to optimally adjust the view. As an example, you can use the menu **Window** to customize size and position of the active window to your needs.
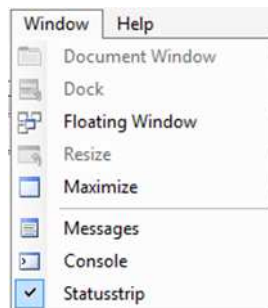
But you can also right-click the windows directly and make the following adjustments.

- **Move window:** drag the active view by its title bar and drop it in the desired position. This also works using the context menu (right mouse click) of the arrow symbol in the title bar. Double clicking the title bar re-docks the view in its standard position.

- **Hide window:** click the **AutoHide** button. It is depicted as a pin symbol on the title bar.
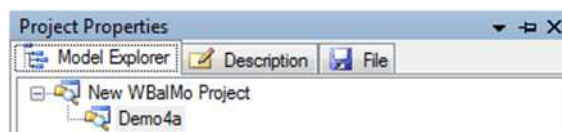
- **Redisplay window:** Double click the downscaled title bar.

- **Maximize/ minimize floating window:** grab the frame while keeping the left mouse button pressed and draw the frame to the desired size, as known from Windows.

You can save the settings for the positions of the feature and tool views (not the model documents!) for the next session. Go to **Extras | Configuration** and activate **View: Save window positions.**

Project

Projects serve for clarity and as organizational frames for the models they contain. As an example, you can collate several models in one project which hydrologically belong to a larger river basin. The purpose of a project is only to facilitate work organization – working within a model it makes no difference which project it belongs to.

The menu item **Project** offers the following sub menus:
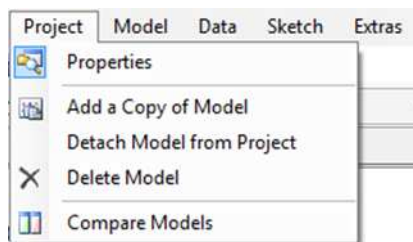
Creating a Project

An empty project is generated each time you start **WBalMo**. To generate a new project click **File | New project**. In **Project | Properties** you can rename your project and edit the project features.

You can save these project features in a project file along with references to model files, where applicable.

Saving and Opening a Project

You can open an already existing project via **File | Open project**. Access recently used projects can be selected under **File | Recent projects**. Use the menu items Save project or Save project as. If necessary, you will be asked to save the modified project upon opening, creating, or closing the project, or at closing **WBalMo**.

- **Save project**: Project is saved at the given directory site.

- **Save project as**: Project is saved as a copy at the directory site you specify.

Project files have the file extension .xml.

Project Properties

In **Project | Properties** you find the three tabs **Model explorer**, **Description** and **File**.
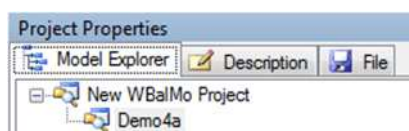
- **Model explorer:** this tab shows you which models the present project contains and allows you to add, delete, or rename models and to access their properties.

- **Description:** here you can enter the project name and a comment on the project**.**

- **File:** on this tab you find the directory location and properties of the project file.

Model

WBalMo projects contain models that allow you to make modifications of any extent, e.g. for the purpose of comparative explorations. It is recommendable to compile models with related topics in one project.

Using the **Model** document you can access these data. The document is split in three areas:

- **Navigator** with the list of all data in a tree structure and to identify the active object

- Tab **Data** offering the possibility of editing all string data in the active object

- Tab with the **System sketch**, which can contain all graphically representable model objects. Apart from that the sketch can also be used for navigation inside the model data.

All of a model's properties, including its data, are saved as **binary** or **XML** files.

Only one model at a time is active within a project. Opened property dialogs (e.g. Model properties) and Tools (e.g. Search) always apply to the active model.

Creating a Model

To create a new model, click on **File| New model** on the menu bar or directly on the **New model** button.

The created model is added to the project. A model document is generated and opened.

Importing a Model from a Predecessor Model

Existing models can be imported from earlier **WBalMo** versions 1.0 (ArcGRM), 2.2 und 3.1.

To import, use the directory browser offered in the menu **File | Import model** to select the file directory with the according ESRI shapes and dBASE files of previous program versions. A successfully imported model is added to the present project and can be worked with immediately. Imported models can be saved as **WBalMo**4 models. After import, please check and rectify the following model data:

- Check file references for discharge series and registrations

- Adapt registration terms to the new syntax

- DYN elements must be adapted to new syntax and provided as binary libraries**.**

Saving and Opening a Model

You save an active model just like a project either by using the menu **File | Save** or **Save as**, or ultimately in the dialog appearing when you shut the program. As an alternative you can use the following buttons:

Save model: saves the active model.

Save all: saves all open models and the project.

In order to guard against the threat of information loss in case the program is unexpectedly interrupted, it makes good sense to save a model before running the simulation.

If you want the current model to be saved by default before any simulation run, activate the option save **Before simulation run** in the menu **Model | Model properties | File**.

Using **File | Open model** or the button you open a model you have already saved. The model *.xml of your choice is uploaded from the expanded Windows explorer. In the left field the model name will appear as a tab reader above the input data list. In the right field, according to your choice either the data or sketch sheets are displayed.

File | Recent models gives you access to recently used models, if you have previously established a user profile (**activate Extras | Configuration | General | Configuration for current user**).

Copying a Model

This is how you copy a model:

- Menu **Project | Add a copy of model**.
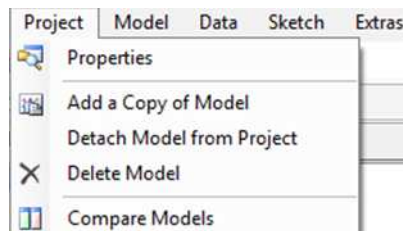
- All model properties and all data are copied. If desired, you can change the storage location when you save the model.

Deleting a Model

Removing a Model from a Project

If you want to remove a model from a project without deleting the model file:

- Menu **Project | Detach model from project**

- In case properties or data of the model were changed you can save these changes in the model file by confirming the prompt.

Deleting a Model File

The menu **Project | Delete model** enables you to remove the model from the project and subsequently move the model file into the recycle bin.

Model Properties

Access the model features using the menu **Model | Model properties** or click on the **Model properties** button.

The model properties dialog offers tabs with the following contents:

- **Description:** Name, Comment.

- **File:** Properties of the model file.

- **Summary:** Model status, number of model elements

- **Time base:** Time-related information and settings in the model

- **Data:** Specifications on Ranking, Flow times and Data check mode

- **Sketch:** System sketch settings

- **Classifications:** Settings for metadata and representations of object groups in the system sketch

- **Simulation:** Settings for simulation run and file locations.
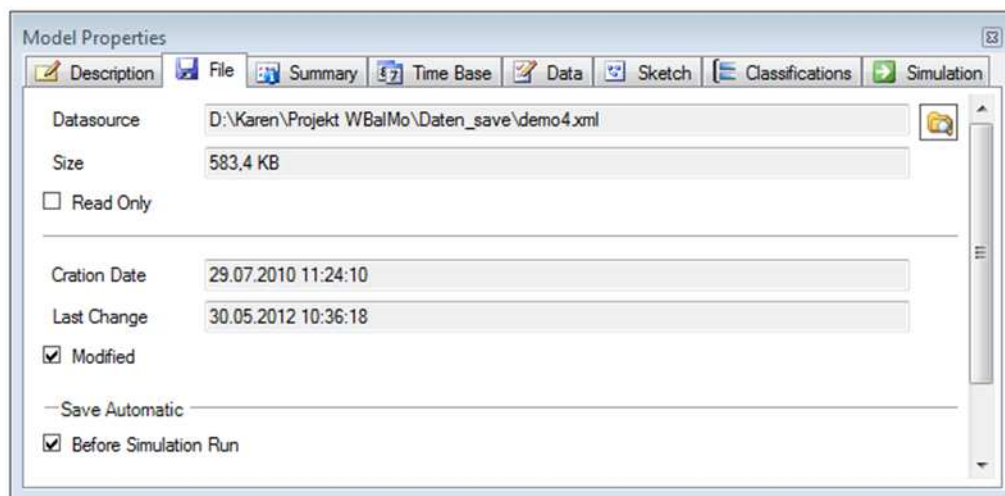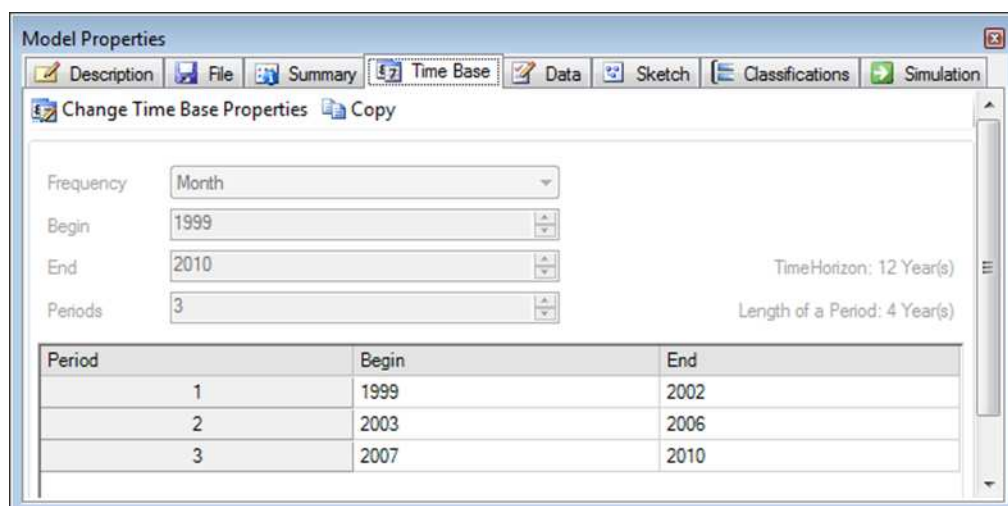
General Information

Enter general information about the model in the first three tabs **Description, File,** and **Summary** of the sub menu **Model properties**.

- You can give a name to the active model and enter or read a comment on the model on the **Description** tab. Features of the model file are laid down in the File tab.

- The tab **Summary** encompasses model status, type, and number of model elements. In the DEMO modus you will find additional information about restrictions here.

Time Base

In the **Time base** tab in the **Model | Model properties** menu you enter information on beginning and ending of the balance **Period**, as well as number, opening and closing dates of the periods it contains. Click the **Change time base properties** button to change these parameters.

Now you can change the entries in the **Time base** dialog.

The entry **Frequency** refers to the intervals of time series in the data storage. Model data can be stored in monthly as well as weekly steps; likewise a weekly or monthly step can be defined for the simulation. External existing data on sub area discharges and universal time series must coincide with this time structure. You may specify the windows of validity of deterministic data from users, reservoirs, and release elements individually under consideration of the time horizon set for your model. The Time base tab allows the following action:

- Definition of the model's **Time horizon** (start = basic year, end)

- Definition of the **Number of periods**, this number must be an integral divisor of all years within a time horizon

- Definition of the **Frequency** for time series data in the model.

You can modify these features for an existing model. Please note that time series of model data are usually changed physically, and check the model data after transformation.

Data Settings

Entries on ranking numbers, flow time, and data check are made on the **Data** tab In the **Model | Model properties** menu:
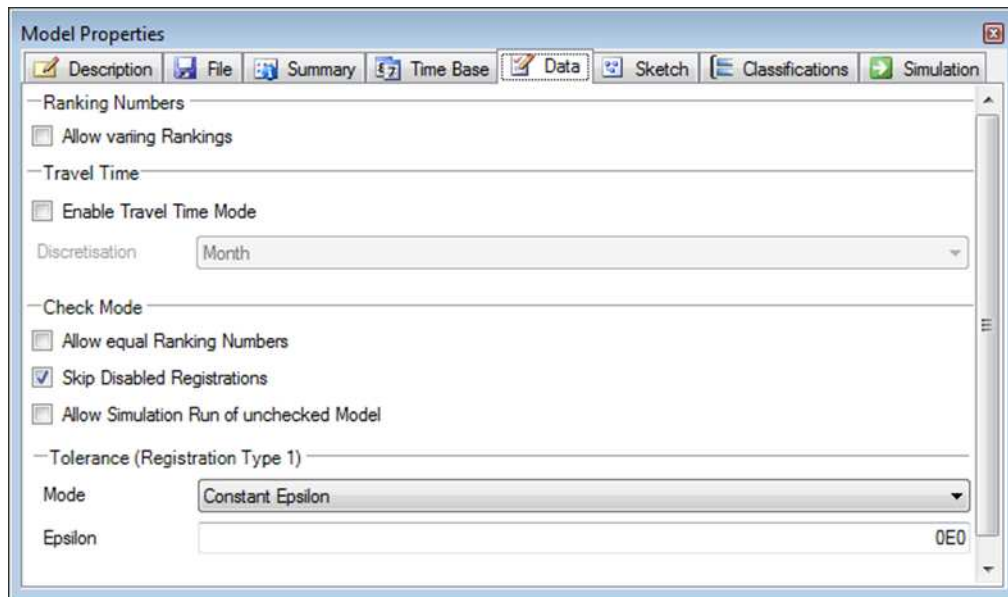
- **Allow varying rankings:** this option allows you to define ranking lists with individually varying temporal patterns. In practice this option is usually less significant.

- **Enable flow time mode:** activate this option if you wish to reproduce large river basins with flow time influence in **WBalMo.** Then you can parametrize selected balance profiles (so-called reference profiles) with according flow times all the way to the model exit. The dialogs **Profile, Sub area discharge**, and **Universal time series** along with the registration dialogs offer additional entry panels for these reference profiles.

- **Skip disabled registrations:** when you activate this option, registration types deactivated in the model will not be considered in the data check**.**

- **Allow simulation run of unchecked model:** this setting should only be chosen if no modifications were made in the model data. This option makes sense if strictly external program parts (compiling of source code for DYN elements) or external data (discharge series for sub area discharges) were changed.

Classification of Data

All model data can be **classified** according to your own specifications. This classification by metadata gives you various options, e.g. the following:

- Grouping of diverse model objects into a greater complex.

- Example: 1 reservoir + 5 users + 3 balance profiles + 2 DYN elements map the surface mine XY in the model and are given the group name "SmXY".

- Grouping of e.g. users of the same type.

- Example: all inland fisheries are given the group name Infi". A search gives you the possibility to use existing classifications as search criteria.

- Representation of model objects with various symbols in the system sketch.

You can create a classification by two different ways:

- specify a shortname in the data dialog, or

- create the according list independently of existing model data.

The menu path **Model | Model properties** gives you options to edit the classification list of the active model on the Classifications tab. Tools with various functions are offered above the classification table. Existing classification groups can be edited in the table.

Create **New classification list:** a new classification list can be created, and the model's existing classification list is overwritten.

Open: opens an existing classification file.

Save: classifications (*.wbgroup.xml) are saved at a location specified by you and become available e.g. for use in other models.

Refresh from model: the classification list is aligned to shortnames of model data.

Add a new row to the table.

Copy an active row.

Paste: insert new row.

Delete an active row.

Refresh sketch: changes in the sketch are adopted.

Check: Classification list is checked for formal correctness (names may not be issued repeatedly).

You can create and edit a model-independent list using the menu path **Extras | Classifications**. Classification lists edited here can be made available as files for use in several models. The functions offered here are merely reduced by **Create list from model** and **Update sketch**.
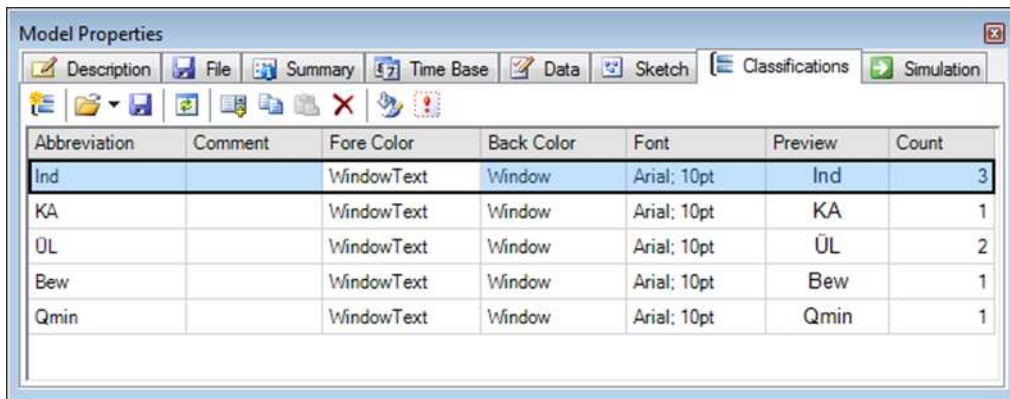
Simulation Run

Make the following settings for the simulation run:

- Open the tab Simulation using the menu **Model | Model properties.**
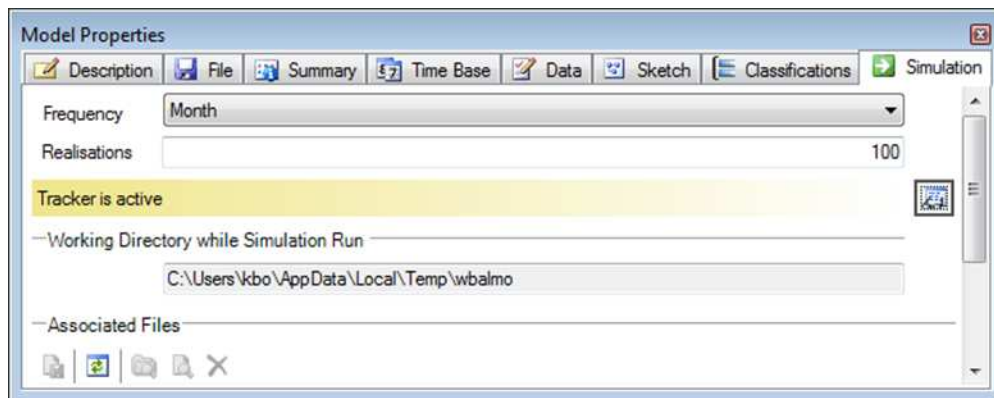
- Select the **Frequency** for the simulation run.

- Specify the number of **Realizations** you want calculated. This number may exceed neither the length of the discharge series for the sub areas nor the data series of the universal time series under consideration of the model's time structure.

 The Configure tracker button allows you to configure the tracker. Tab Files contains information on the locations of the result files and the directory, as well as the time of last modification and the file size. Using the buttons you can carry out the following actions:

     Set output file

     Refresh data

     Open directory in explorer

     Open file

     Delete file**.**

Model Data

General

Overview of Data Groups:

The data needed to build a management model in a river basin according to a preset management strategy are subdivided in data groups, which are explained in more detail in the sector **Basis of the management model**.

•	Rivers	Model structure
•	Balance profile	Model structure
•	Regions with equal flow time	Model structure
	Flow time influence	
•	Sub area discharge	Discharge
•	Universal time series	e.g. climate data, special rules
•	User	Management
•	Reservoir	Management
•	Release element	Management
•	Combined reservoir management	Management
•	Constant (double)	Special rules
•	Constant (string)	Special rules
•	DYN element	Special rules
•	Measure unit	
•	**Registration Type 1**	Result output
•	**Registration Type 2**	Result output
•	**Registration Type 3**	Result output
•	**Registration Type 4**	Result output
•	**Registration Type 5**	Result output

Dependency of Data:

Data of one data group are often based on that of another data group:

Data group	Based on the existence of
Balance profile, reservoir	River
Flow time region	Balance profile
Sub area discharge	Balance profile
User	Balance profile

Reservoir	Reservoir group
Release element	Reservoir

Dependency on measure units is not represented here.

Views and Access to Data

Using the model document, you can access data and utilize functions. The model document consists of three areas:

- **Navigator** with a list of all data sorted by data groups. Activate an element in the navigator to view and edit its data in the active tab.

- **Data** tab with the option to edit all of the active object's alphanumeric data.

- **Sketch** tab with the system sketch that can contain all graphically representable model objects (rivers, balance profiles, sub area discharges, universal time series, users and reservoirs). Whenever the sketch tab is activated, the active object appears highlighted.

An array of tools enables immediate access to the according data of the active model in **WBalMo**. Activate an object by double-clicking, e.g. in the following list:

- Filter model elements by your own criteria in **Data | Search** and work concentrated with this selection. Double-clicking on your search object opens its data or sketch tab.

- **Marked objects**: Set bookmarks and work with your favorites.

- **Error list**: Correct data errors.

The menu item **Edit** gives you further editing options for your active object**:**

- **Edit in separate form** opens a separate window for the alphanumeric data of the active model. This function makes sense e.g. when the **Sketch** tab is activated.

- **Mark object** assigns a bookmark to an active object. Bookmarked objects can be viewed and edited as a list in menu item **Data | Marked objects**.

- **Data check**: with this function you can check the data of selected model elements or the complete model and find possible errors in the data or in the model before running a simulation.

- **Copy, Insert**: You can use the Windows clipboard to copy **WBalMo** objects.

- **Delete**: The active object is deleted after your confirmation.

- **Sort, Expand nodes, Collapse nodes** change the representation in the navigator.
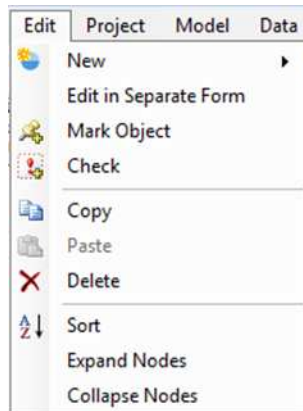
Creating and Deleting Data

A model contains objects with and without spatial references. If an object belongs to a data group that in principal can have a spatial reference, its corresponding geometry may also be defined later.

Model element without Spatial Reference:

Elements that cannot be graphically represented, such as DYN elements, constants, or registrations can still be assigned to the activated model.

Create new elements:

- Select the data group in menu **Edit | New**. Double-clicking on the object in the navigator opens the corresponding data sheet.
- Model objects, including their data, can be inserted (pasted) using the clipboard.

Model element with Spatial Reference:

The data groups, river, balance profile, sub area discharge, universal time series, use, and reservoir can be graphically represented in the system sketch.

- Activate the tool which corresponds to the desired model element (see below) and the task **New**. On the sketch tab, determine the new element's location in the system sketch with a left mouse-click. Now you can enter factual data on the model element in the dialog mask.

Tools:

	River
	Balance profile
	Sub area discharge
	Universal time series

User

Reservoir

- As an alternative you can add a new object to the model by using menu item **Edit | New**. This features no geometry and thus cannot be represented in the system sketch. For these kinds of objects, you can also create a geometry in retrospective using the menu **Sketch | Sketch settings** on the tab of **Invisible objects**.

- Model objects complete with their data and geometries can be inserted (pasted) from the clipboard.

Delete Data:

- Activate the element of interest in the navigator. Select **Edit| Delete** from the menu.

If the element you want to delete is connected to other data you will be informed by a note.
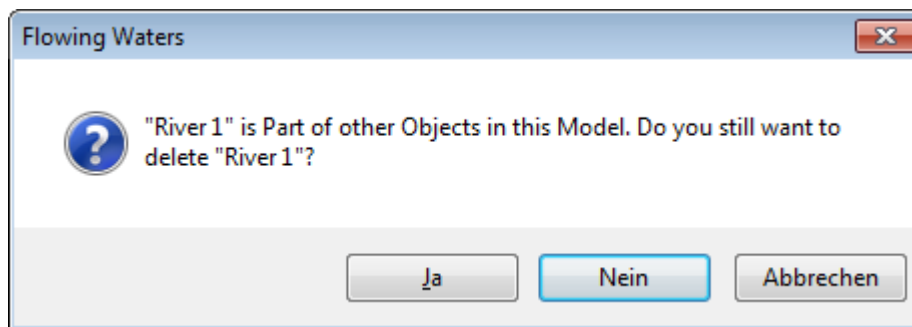
You can obtain information about an object's links to other data using **Data | References**.

Working with the Clipboard

The clipboard is a space where information you have copied or taken from one place and wish to use elsewhere is temporarily stored. The clipboard in **WBalMo** works in analogy to the clipboard in Windows programs: you can mark a text, **Copy** it into the clipboard, and insert it in a different place with **Paste**. This way, for example model objects are easily copied within a model or from one model to another.

Copy transfers the marked model elements into the clipboard. All object data including the object's geometry are copied.

Paste inserts the model elements from the clipboard into a model. Source and target models that contain data with temporal variations must feature identical time structures. Inserting data based on different time structures is not possible. In this case an error message appears.

Time-Variant Data

In **WBalMo**, all time-variant data, such as user withdrawals and return flows, reservoir release volumes, etc. use time series of identical structure with the columns **Period, Begin** (of an interval), and **Withdrawal**, with one assigned value, respectively, per date row. Therefore their handling does not differ much.

General information on the object is entered in the upper part of the data dialog. In the bottom part you specify measure unit and data type. Tables for discharges, withdrawals, return flows or minimum discharges will appear on the data sheet according to the data type.

In the data dialog you can choose between **Standard view** and **Period view**. Both modes offer you an array of editing possibilities. In the standard view you have the following functions available apart from the context menu:

	Add row inserts another row in the table using the current date (which you are free to change)
	Delete row deletes the active row (in case several rows are active, only the first one is deleted). The starting value of the time series cannot be deleted.

This gives you the option of adding intervals with corresponding values to your table or to change date information or values. The rows are automatically sorted in chronological order.

Insert new row:

Period	Begin		Withdrawal
	1	01.01.0001	0,0000
1	1	01.01.1999	1,5000

Change date:

Period	Begin		Withdrawal
1	1	01.01.1999	1,5000
3	1	01.01.2009	0,0000

Change value:

Period	Begin		Withdrawal
1	1	01.01.1999	1,5000
3	1	01.01.2009	1,2000

The **Period view** offers the following options:

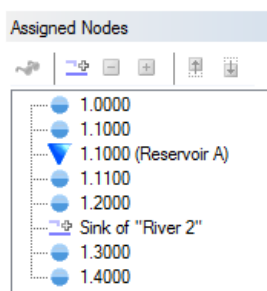|	
P	In the **Period view** you can choose from a dropdown list between views of individual periods or of all periods inside the balance period.
	Select the period you want to work on using the dropdown list or **Arrow keys**.
	Integrate time steps: only one value is valid throughout the whole year instead of monthly or weekly values.

	Equal values in periods: with this setting, if the value for one time step (e.g. January of one year) is changed, this new value will be adopted for all according time steps (all months January) in all existing periods.

No rows can be added or deleted in the period view.

Note: Keep in mind that the function **Integrate time steps** changes not just the view, but the actual data. On activating this button, the January value, or value of the first week respectively, is adopted and data belonging to the following time steps will be overwritten.

Model Elements

Model elements can be created or deleted using the navigator or the system sketch by means of the tools in the menu bar (**Edit | New | ...**) or corresponding pop-up menus.

Assigned Nodes

- 1.0000
- 1.1000
- 1.1000 (Reservoir A)
- 1.1100
- 1.2000
- Sink of "River 2"
- 1.3000
- 1.4000

The data belonging to the model element are edited either on the Data tab or in a dialog (menu **Edit | Edit in separate form**).

The upper section contains the model element's master data:

- The **Key** is a unique identifier inside the data group. It mainly serves to access the model object data in registration terms and DYN elements.

- Name, Comment, and Group are meta-information on the object.

- In **Group** you can enter either a shortname or select from the list of existing shortnames.

River

The model structure is defined by **Rivers**. The drawing direction is interpreted as flow direction. Balance **Profiles** and **Reservoirs** of interest can be applied and assigned on the rivers represented by these polylines:

- Enter details for the river on the data sheet as described at the beginning of the section **Model elements**. In **Mouth**, specify a river mouth by selecting the (main) river which your (tributary) river discharges into.

- To edit the **Nodes** assigned to the rivers you have the following options in the **Data** dialog:

Activate a node (not possible in the tree structure view)

View structure as tree reproduces the hierarchic structure of rivers, balance profile, and reservoirs

Expand nodes opens all river mouth nodes in the tree structure view and shows the nodes on the tributaries
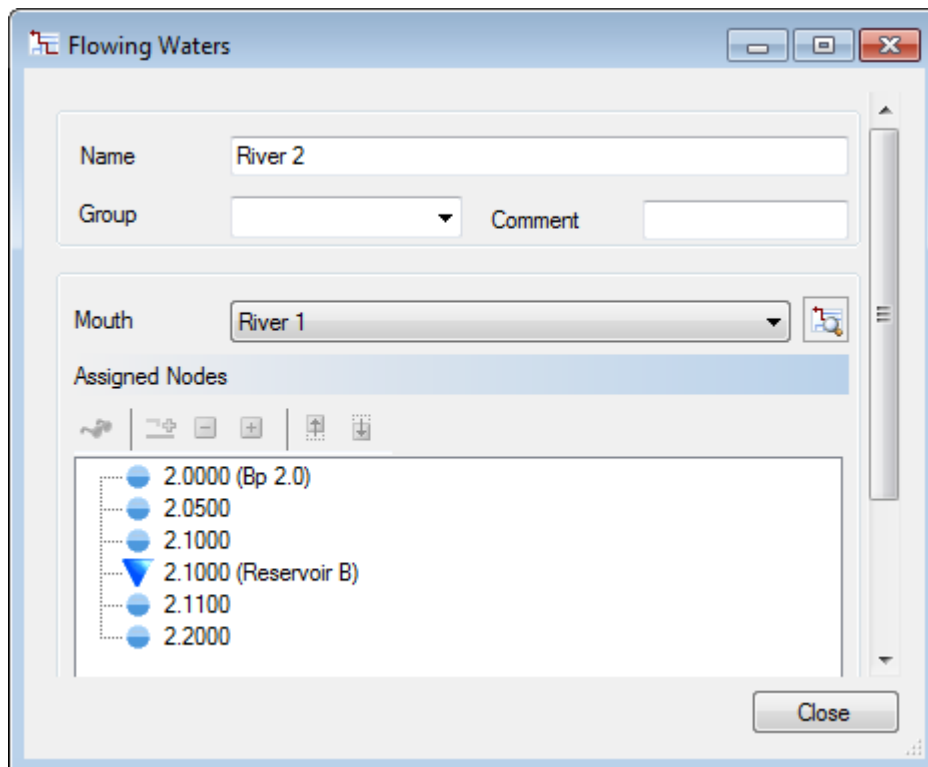
Collapse nodes closes all nodes in the tree structure view

Move node up moves nodes up one position against flow direction

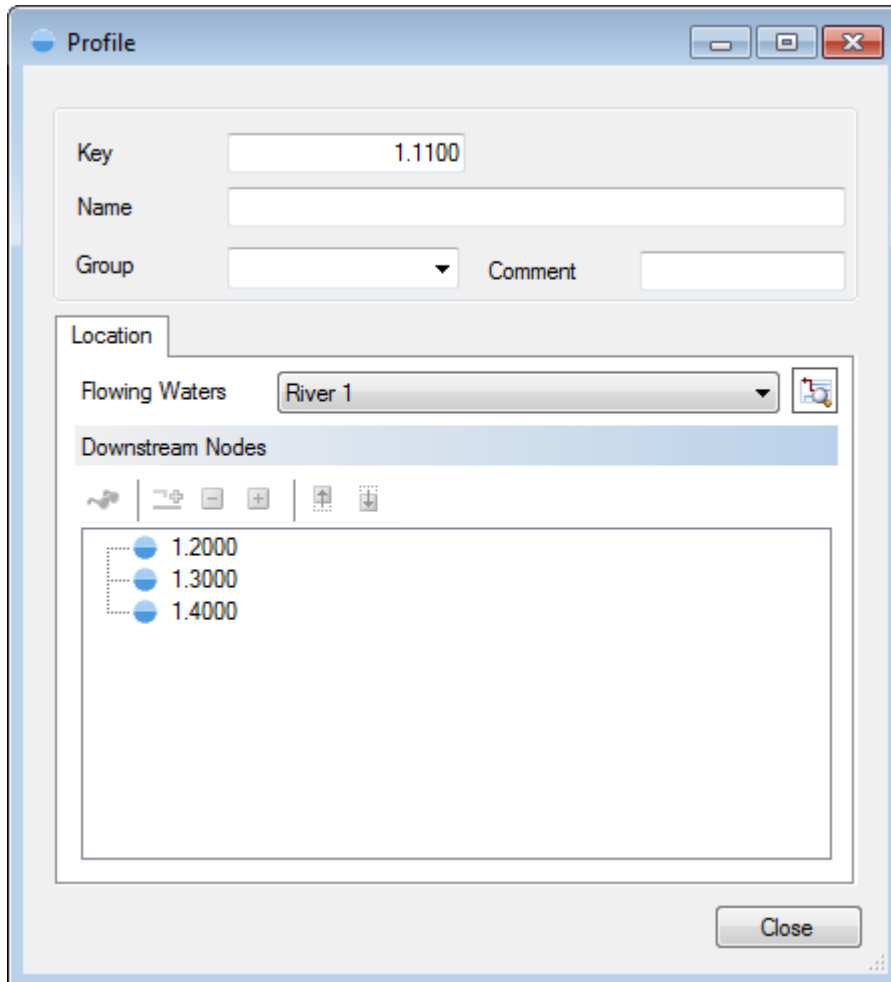**Move node down** moves nodes down one position with the flow direction.

Note: Proceed as follows when building the system structure:

- Create the rivers. Allocate tributaries and main rivers.

- Create balance profiles and reservoirs. Assort these to the rivers.

- Sort the nodes of balance profiles, reservoirs, and river mouths of the rivers in flow direction.

Balance Profile

Using the balance **Profiles**, discharges from sub areas can be distributed by area ratios, and locations of water resources **utilizations** can be determined in the river basin. Besides, **Registrations** of discharges can be made at balance profiles.

Assign the balance profile to a river by selecting it from the dropdown list. Determine the balance profile's correct location on the river polyline.

All downriver balance profiles and reservoirs up to the end of the model area are displayed.

Regions with Equal Flow Time

If you want to consider the influence of flow times in the management model, select the option **Consider flow times** in the model properties. In the balance **Profile** dialog the additional tab **Region with equal flow time** will then appear, on which you can enter details on the flow time. By means of a reference profile all sub area discharges, universal time series, and registrations must be assigned to a region in the flow time mode.

Explanations:

- **Flow time** until closing profile is optionally stated in months or days

- If no flow time is given for a balance profile, the flow time of the profile's region is applied.

-

In flow time mode the regions with equal flow times are displayed. The region's key number is identical with that of its closing profile. Next to the balance profiles and reservoirs located inside the region, the data panel also shows you the regions downstream from it. For better overview, **tooltips** will give you the flow times for the individual regions with equal flow times whenever you let the mouse hover there.

Note: Please note that random ranking orders can no longer be defined in the model if flow times are considered.

Sub Area Discharge

A **Sub area discharge** represents the natural water discharge of a river sub basin.

Reference profile (only visible in flow time mode):

- Select a balance profile from those offered in the dropdown list as the reference profile.

- A flow time should be entered for the balance profile selected as the reference profile.

- The profile furthest downstream in the sub area is the one best suited.

Discharge series:

- Refer to an ASCII file containing this sub area's discharge data.

- Select the measure unit the discharge data are provided in.

File:

- The selected file must be an ASCII file with a table of figures.

- Decimal separators ".", columns are separated by space, tab or comma.

- 12 columns January ... December for simulation in monthly steps or 52 columns for simulation in weekly steps

- The rows are the chronologic succession of years in each realization or, for the simulation of a balance year respectively, the succession of individual years to be simulated.

As for the data source for a **Sub area discharge**, you have the following options:

With **Assign file**, you can find and name the data source of interest by browser.

View opens the corresponding time series table tfor you to view.

Open directory in explorer allows you to navigate in the explorer and manage the files**.**

Relative shares of balance profiles:

- Enter the relative share of the discharge at the balance profiles. Employ the given area ratios for this.

- If no shares are indicated for a sub area discharge, all balance profiles are shown.

- **Show null values** displays all balance profiles in the list, giving you the option of defining further discharge shares.

- **Hide null values** only display those balance profiles with a discharge share unequal zero.

User

Users represent influences on management by water demand and water distribution inside the model.

Type: here you can decide between user types **Withdrawal and return flow, Inflow,** and **Minimum discharge.** According to the defined type, spaces appear in which to specify locations and quantities of withdrawals, return flows, and minimum discharges.

Withdrawal and return flow profiles: select the according balance profiles from the dropdown list. Note that for user type Withdrawal and return flow, the return profile must not be located upstream from the withdrawal profile.

Note: In the flow time mode, no flow time may occur between withdrawal profiles and return flow profiles, and both profiles must be in the same region. If there are not actually located in the same region, and if withdrawals and return flows are not defined by fixed values (see below), you can proceed as follows: split the user into a withdrawal and a return flow user. In any case the return flow rate should be set in the DYN element, because it becomes impossible to assign the actual discharges or return flows another user has caused in a flow time- and volume-dynamic manner after that user has been balanced. In case of water transfers into a different region, a river polyline must be created featuring profiles and corresponding flow times.

Indicate the envisioned **withdrawal and discharge volumes** as **time-variant data** according to the user type you have chosen.

Enter the user's **Ranking number**. The rank list informs you of the position among the ranked model objects.

Note: Examples for possible user definitions (withdrawal and return flows) are entries of (statistical) values in the dialog, or water permission or planning data. Calculations applying to model flow times in DYN elements are made in dependency on other system states:

o   Irrigation = f (N, PET)

o   Inland fishery = f (PET)

o   Diversion = f (Q).

Reservoir

Reservoirs and their regulation as an important management instrument mostly represent the specific preferential treatment of users and groups of users.

Define the river on which the reservoir is located. You determine the exact site of the reservoir within the balance profiles and reservoirs of this river by shifting the nodes as described in the **River** section. Either the balance profile downstream from the reservoir, or else the next downstream reservoir is displayed, respectively.

Specify the storage **Capacity** in hm³. The storage capacity does not enter the balance directly, but serves as a test quantity for the effective storage capacity. The storage capacity indicates the maximum of active storage volume.

The **Initial filling** is a decimal between 0 and 1 which indicates the storage level in relation to the effective storage capacity for the first simulation time step.

Indicate the **Active capacity** as time-variant data in hm³.

Any reservoir is by default a Single reservoir. If you want the reservoir to be part of a reservoir association, proceed as follows:

- Define a model element **Combined reservoirs**, if this has not been previously done.

- **Deactivate** the option **Single reservoir** and assort the reservoir to the **Association** of interest displayed in the dropdown list.

- Specify the **Limited capacity at combined reservoir management** as time-variant data in hm³ for this reservoir.

Combination of Reservoirs

- No other elements must be sorted by their ranking numbers between the ranking numbers of all AEND elements of a reservoir association. You can control this by checking the ranking list in menu item **Data | Ranking list**.

Number of slices IGR and ING

- Up to 128 slices (iteration steps of the calculation for the quasi-proportional replenishment) can be specified.

- **IGR**: Number of slices up to 1st filling stage. If IGR = 0, the 1st stage will not be considered. You define the size of the stage in the form of a **Limited capacity at combined reservoir management** for each reservoir belonging to the reservoir association.

- **ING**: Number of slices up to 2nd filling stage, into which the storage volume from the 1st filling stage (Limited capacity at combined reservoir management) to the reservoir's active capacity is divided. ING = 1 means that the proportional filling of the 2nd stage is terminated.

The reservoirs belonging to a reservoir association are displayed.

- No other elements may be sorted by their ranking numbers between the **Ranking numbers** of **Reservoir end elements** and an **Association**.

Removing a reservoir from an association:

- You can remove individual reservoirs from a reservoir association by activating the option **Individual reservoir** in the **Reservoir** dialog.

Release Element

Using **Release elements** you define the availability of the storage volume for certain users, and thus the extent of reservoir releases.

Assign the release element to a reservoir by selecting one from the dropdown list of existing reservoirs.

Define the **Type** of release element:

A **Reservoir release** or **Backfilling** serves to give users of lower ranks preferential treatment or to accumulate reserves for later time steps. The volumes of released water are defined by the **Target storage level** (in hm³) and the **Coefficient** as time–variant data. The volume set through the release element is equal MAX(target storage level, coefficient • initial storage level of the current time step).

The **END element** shuts down the reservoir for lower rank objects. In the final calculation, available water is stored up to the active storage capacity.

Indicate the **Ranking number** of the release element. The ranking list informs you about the position among the ranked model objects.

Note: No other elements may be sorted by their ranking numbers between the reservoir **END elements** and **Combined reservoirs**.

Measure Unit

Measure units are needed not only for conversion of the model input data for sub area discharges users into the internal measure unit hm³/month used in the simulation, but also for result display in the registration tables. Next to that, non-quantity related measure units can be defined to be used in universal time series, which you can certainly use also for registration tables.

Predefined measure units are

- the quantity-related units m³/s, hm³/month, l/s and Tm³/d , as well as

- the volume hm³ and the percentage value %, and a dimensionless unit to be used for measure values

- it is not possible to edit or delete the predefined measure units.

Activate the option **Discharge quantity** if you are dealing with a quantity-related measure unit. In this case enter a conversion factor for your unit to convert to hm³/month.

This displayed table can be used as a simple converter for the displayed measure units. Spaces that can be edited are marked as such.

All the measurement units can be used to define registrations. Non quantity-related measure units are not converted.

Examples:

- Long term simulated series global radiation kJ/m²/d,

- Concentration of a compound mg/l,

- Groundwater isobaths m.

DYN Element

DYN elements enable you to interrupt the sequence of standard algorithms at a specific point and to process an algorithm preset by you which usually refers to current values of the system's state variables. According to its **Ranking number**, the dynamic element is sorted into the ranking list of all user and reservoir elements and executed.

DYN elements can be assigned to the following four types:

- A **Start element** is executed one-off at the beginning of the simulation. A start element has no ranking number. Maximum one start element is allowed within a model.

- **Pre elements** have a negative ranking number and are executed before the natural discharge is imprinted on the balance profiles in each simulation step.

- **Regular DYN elements** have a positive ranking number and are executed at every simulation step. They file themselves into the list of all user and reservoir elements.

- An **End element** is executed one-off at the end of a simulation. An end element possesses no ranking number. Maximum one end element is allowed inside a model.

Examples:

- o In the Start element, initializing routines can be executed

- o The Pre element calls up a RR model

- o In the End element (own) results are written and files are closed.

To imbed a DYN element, select the .dll file containing the DYN element on the tab **Function**. In the file properties you find informationen on the target platform (32- oder 64-bit systems) and available functions. Select the **Function/ Method** that you want executed as DYN element.
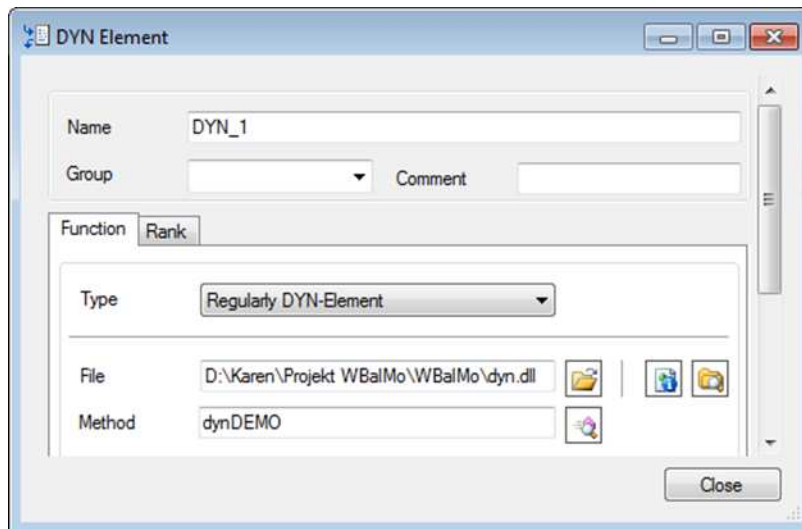
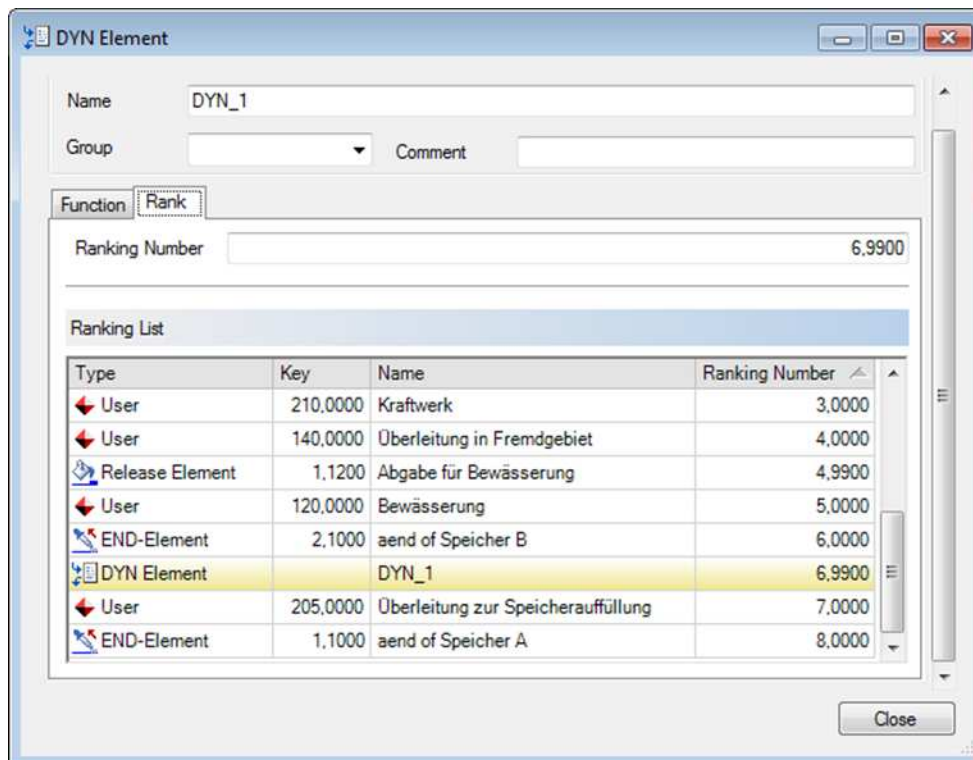With **Assign file** you can find your desired data source by browser and enter it.

File properties opens the properties of program library files and the interfaces of exported functions in the program.
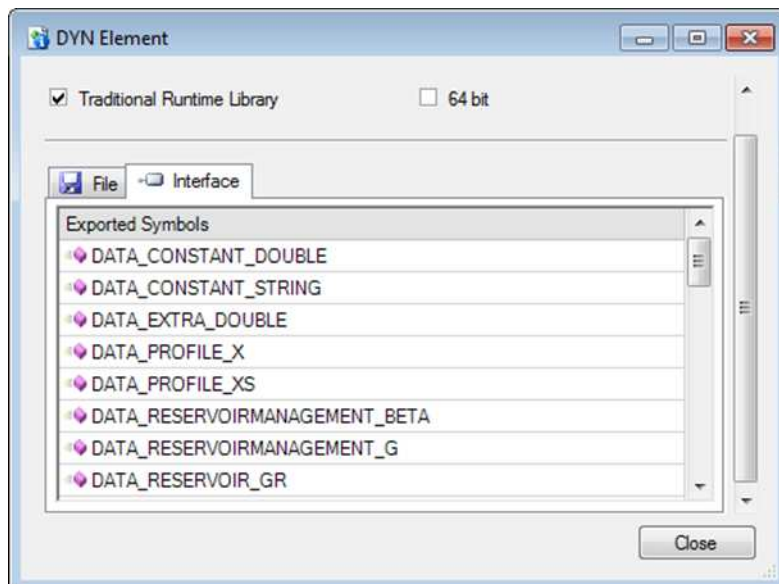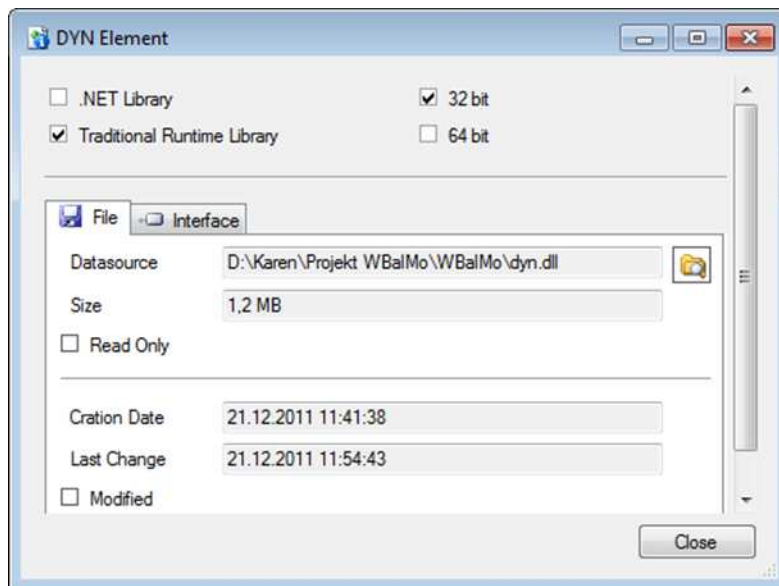
Open directory in explorer.

On the **Rank** tab you assign a ranking number to the DYN element.

The **File properties** window contains the two tabs **File** and **Interface**:

Note:

- Presently templates exist for **WBalMo** which facilitate formulating DYN elements in FORTRAN and C#.

- You can provide DYN elements in several.dll files, combining different languages and technologies.

List of Parameters and Functions

DYN elements must be available as exported functions from runtime libraries (.DLL files). Currently two templates exist to set up DYN element libraries: one template for FORTRAN-DLLs and one for C# class libraries. The following tables give you an overview of the **WBalMo**-specific functions and parameters respectively available there. Next to this you can certainly rely on the instruction sets and extensions provided in the corresponding programing languages.

FORTRAN

Data type	Variable	Measure unit	Meaning	Comment
Time step	RealisationCount		Number of realizations	ANZR [1]
	Realisation		Number of current realization (1...RealisationCount)	NREL [1]
	PeriodCount		Number of periods	ANZP [1]
	PeriodLength		Length of a period in years	LP [1]
	Period		Number of current period (1...PeriodCount)	NPER [1]
	YearPeriod		Year of simulation within the current period (1...PeriodLength)	JAHR [1]
	YearBase		Basic year of model	BASJ [1]
	YearCurrent		Current year	
	Month		Current month (1...12) of current year	MON [1]
	Week		Current week (1...52) of current year	
	YearRealisation		Current year within current realization	
	MonthRealisation		Current month within current realization	
	WeekRealisation		Current week within current realization	
Balance profile	Discharge	hm³/Mon	Discharge	X [1,2,3]

	DischargeProtected	hm³/Mon	Protected discharge	XS [1] [2] [3]
	GetDischargeAvailable	hm³/Mon	Smallest free lamella between two balance profiles	FREI [1] [6]
	GetDischargeMinimum	hm³/Mon	Minimum discharge between two balance profiles	MIN_RUNOFF [1] [7]
	GetDischargeMaximum	hm³/Mon	Maximum discharge between two balance profiles	MAX_RUNOFF [1] [7]
	SetDischarge	hm³/Mon	Change of discharge volume between two balance profiles	CHXX [1] [8]
Sub area discharge	Runoff	hm³/Mon	Natural runoff/ yield	Q [1] [2] [3]
	RunoffShareRelative		Relative discharge share for a balance profile of a sub area discharge	GET_RELSHARE, SET_RELSHARE [1] [4] [5]
Universal time series	SeriesGeneral		Value of a universal time series, model dependent	Q [1] [2] [3]
User	Withdrawal	hm³/Mon	Withdrawal target	E [1] [2] [3]
	ReturnFlow	hm³/Mon	Return flow target	R [1] [2] [3]
	WithdrawalBalanced	hm³/Mon	Actual withdrawal	AE [1] [2] [3]
	ReturnFlowBalanced	hm³/Mon	Actual return flow/ discharge	AR [1] [2] [3]
Reservoir	Capacity	hm³	Reservoir capacity	SK [1] [2] [3]
	StorageEffective	hm³	Effective	NG [1] [2] [3]

			storage capacity	
	StorageIntermediateLevel	hm³	Subdivision of usable volume at combiniated operation	GR [1) 2) 3)]
	StorageCurrent	hm³	Storage level before or after calculation in one month	SI [1) 2) 3)]
	StorageInitial	hm³	Initial storage level in the beginning of a month	SIA [1) 2) 3)]
Release element	StorageTarget	hm³	Storage level target	G [1) 2) 3)]
	StorageTargetRelative		Coefficient for calculation of minimum or maximum storage target in dependency of StorageInitial	BETA [1) 2) 3)]
Variable parameter	ConstNumber		Freely available numeric parameter	C, CC [1) 2) 3)]
	ConstString		Freely available string parameter	CTXT [1) 2) 3)]

1) Equivalent in earlier versions

2) Read: Value = Function(Key)

3) Write: Value = Function(Key, value)

4) Read: Value = RunoffShareRelative (Key sub area, Key balance profile)

5) Write: Value = RunoffShareRelative (Key sub area, Key balance profile, value)

6) Read: Value = GetDischargeAvailable (Key sub area 1, Key sub area 2)

- Calculation of the smallest free lamella flamelle at all balance profiles of Bp1 in flow direction up to Bp2. Discharge at this section of Bp1 and Bp2 may be reduced by maximum this lamella without compromising already balanced utilizations.
- Is given as Bp2 "-999", provides GetDischargeAvailable the smallest free lamella to the end of the line.

7) Read: Value = Function (Key balance profile 1, Key balance profile 2)

8) Write: SetDischarge (Key balance profile 1, Key balance profile 2, value)

- Change of discharge volume at all balance profiles from Bp1 in flow direction to Bp2 by the volume value.
- If "-999" is entered in Bp2 SetDischarge is applied up to the next end of line.

C#

File type	Variable	Measure unit	Meaning	Comment
Time step	VarPublic.RealisationCount		Number of realizations	ANZR [1]
	VarPublic.Realisation		Number of current realization (1... RealisationCount)	NREL [1]
	VarPublic.PeriodCount		Number of periods	ANZP [1]
	VarPublic.PeriodLength		Length of a period in years	LP [1]
	VarPublic.Period		Number of current period (1... PeriodCount)	NPER [1]
	VarPublic.YearPeriod		Year of simulation within the current period (1...PeriodLength)	JAHR [1]
	VarPublic.YearBase		Basic year of model	BASJ [1]
	VarPublic.YearCurrent		Current year	
	VarPublic.Month		Current month (1...12) of current year	MON [1]
	VarPublic.Week		Current week (1...52) of current year	
	VarPublic.YearRealisation		Current year within current realization	
	VarPublic.MonthRealisation		Current month within current realization	
	VarPublic.WeekRealisation		Current week	

			within current realization	
Balance profile	VarPublic.Discharge	hm³/Mon	Discharge	X [1] [2] [3]
	VarPublic.DischargeProtected	hm³/Mon	Protected discharge	XS [1] [2] [3]
	VarPublic.GetDischargeAvailable	hm³/Mon	Smallest free lamella between two balance profiles	FREI [1] [6]
	VarPublic.GetDischargeMin	hm³/Mon	Minimum discharge between two balance profiles	MIN_RUNOFF [1] [7]
	VarPublic.GetDischargeMax	hm³/Mon	Maximum discharge between two balance profiles	MAX_RUNOFF [1] [7]
	VarPublic.SetDischarge	hm³/Mon	Change of discharge volume between two balance profiles	CHXX [1] [8]
Sub area discharge	VarPublic.Runoff	hm³/Mon	Natural runoff/ yield	Q [1] [2] [3]
	VarPublic.GetRunoffShareRelative		Relative discharge share for a balance profile of a sub area discharge (read)	GET_RELSHARE [1] [4]
	VarPublic.SetRunoffShareRelative		Relative discharge share for a balance profile of a sub area discharge (write)	SET_RELSHARE [1] [5]
Universal time series	VarPublic.SeriesGeneral		Value of a universal time series, model dependent	Q [1] [2] [3]
User	VarPublic.Withdrawal	hm³/Mon	Withdrawal target	E [1] [2] [3]
	VarPublic.ReturnFlow	hm³/Mon	Return flow target	R [1] [2] [3]
	VarPublic.WithdrawalBalanced	hm³/Mon	Actual withdrawal	AE [1] [2] [3]
	VarPublic.ReturnFlowBalanced	hm³/Mon	Actual return flow/ discharge	AR [1] [2] [3]
Reservoir	VarPublic.Capacity	hm³	Reservoir capacity	SK [1] [2] [3]
	VarPublic.StorageEffective	hm³	Effective storage capacity	NG [1] [2] [3]
	VarPublic.StorageIntermediateLevel	hm³	Subdivision of usable volume at combiniated operation	GR [1] [2] [3]

	VarPublic.StorageCurrent	hm³	Storage level before or after calculation in one month	SI [1) 2) 3)]
	VarPublic.StorageInitial	hm³	Initial storage level in the beginning of a month	SIA [1) 2) 3)]
Release element	VarPublic.StorageTarget	hm³	Storage level target	G [1) 2) 3)]
	VarPublic.StorageTargetRelative		Coefficient for calculation of minimum or maximum storage target depending on StorageInitial	BETA [1) 2) 3)]
Variable parameter	VarPublic.ConstNumber		Freely available numeric parameter	C, CC [1) 2) 3)]
	VarPublic.ConstString		Freely available string parameter	CTXT [1) 2) 3)]

1) Equivalent in earlier versions

2) Read: Value = Attribute[Key]

3) Write: Attribute[Key]= value

4) Read: Value = GetRunoffShareRelative (Key sub area, Key balance profile)

5) Write: SetRunoffShareRelative (Key sub area, Key balance profile, value)

6) Read: Value = GetDischargeAvailable (Key balance profile 1, Key balance profile 2)

- Calculation of the smallest free lamella flamelle at all balance profiles of Bp1 in flow direction up to Bp2. Discharge at this section of Bp1 and Bp2 may be reduced by maximum this lamella without compromising already balanced utilizations.

- Is given as Bp2 "-999", provides GetDischargeAvailable the smallest free lamella to the end of the line.

7) Read: Value = Function (Key balance profile 1, Key balance profile 2)

8) Write: SetDischarge (Key balance profile 1, Key balance profile 2, value)

- Change of discharge volume at all balance profiles from Bp1 in flow direction to Bp2 by the volume value.

- If "-999" is entered in Bp2 SetDischarge is applied up to the next end of line.

Universal Time Series

Using **Universal time series** you can integrate e.g. climate or temperature series in the model and make these data available to DYN elements.

Reference profile (only visible in flow time mode):

- Select a balance profile from those offered in the dropdown list as the **Reference profile**.

- A **Flow time** should be entered for the balance profile which was selected as the **Reference profile**.

- The profile furthest downstream in the sub area is the one best suited as a reference profile.

Data series:

- Refer to an **ASCII file** containing this time series' data.

- Select the measure **Unit**.

File:

- The selected file must be an ASCII file with a table of figures.

- Decimal separators ".", columns are separated by space, tab or comma.

- 12 columns January ... December for simulation in monthly steps or 52 columns for simulation in weekly steps

- The rows form a chronologic succession of years in each realization or, for if a balance year is simulated, a succession of the individual years to be simulated.

As for the data source for a **Universal time series**, you have the following options:

With **Assign file**, you can find and name the data source of interest by browser.

Display opens the corresponding time series table tfor you to view.

Open file in directory allows you to navigate in the explorer and manage the files**.**

Numeric Parameters

By means of **Numeric parameters**, data can be passed to or between DYN elements as well as registrations, respectively.

Specify the parameters as time-variant data.

String Parameters

String parameters are alphanumeric parameters such as file or path names or formatting instructions and serve for use in DYN elements.

Specify the parameters as time-variant data.

Registrations

In this section you will find comments related to all types of registrations. The sections "**Registration Type 1**…5" deal with the specifics of the individual registration types.

Create a new registration:

- Via menu path **Edit | New | Registration** a new registration is added to the model.

Delete a registration:

- Activate the registration you want to delete in the navigator and select the menu item **Edit| Delete**.

Name and **Comment:**

- These data represent meta-information.

Registration term: A registration term is a term applied to the system states of interest and variables. Depending on the type of registration it is either an arithmetic term (the result is a figure) or a logical term (the result is "true" or "false").

- You can access system states applying the **VarPublic** class using the parameter Key and **WBalMo** parameters.

- The **Math** class contains all mathematical functions available in .NET.

- You can edit the term directly or using the formula editor 🖉. The formula editor supports you with some information on the provided functions.
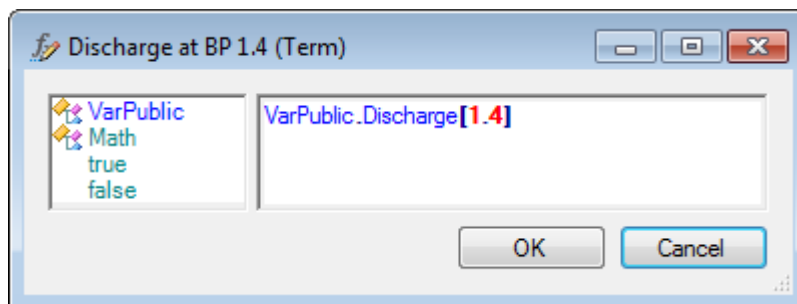
Activate registration:

- Within a model, a multitude of registrations can be defined. Especially if several persons working with one model but with various focusses want their results evaluated and displayed, this is done much more efficiently by specifically displaying or hiding registrations. Another example were this would make sense is after models have undergone modifications of a larger extent (or have been re-established), where first registrations offer at least rough indication for a model's plausibility but no other registrations need to be deleted.

- Simulation calculations consider only active registrations.

File:

- Specify location and file name for result output.

- All tables of registration **Types 1, 2, 3** and **5** are stored in one file.
- Registration tables **Type 4 and Tracker** tables are storage individually, respectively, due to the large file size expected.

Reference profile (only visible in flow time mode):

- In flow time mode, a registration must be assigned to a **Region**. Select this region considering the variables used in the registration term, or more precisely their spatial references.
- For this, select a balance profile as the **Reference profile** from the dropdown list. A flow time should be entered for the balance profile selected as the reference profile.
- It usually makes little sense to use variables of objects that have a **Flow time** between them.

Data type	Variable	Measure unit	Meaning	Comment
Time step	VarPublic.RealisationCount		Number of realizations	ANZR [1]
	VarPublic.Realisation		Number of current realization (1... RealisationCount)	NREL [1]
	VarPublic.PeriodCount		Number of periods	ANZP [1]
	VarPublic.PeriodLength		Length of a period in years	LP [1]
	VarPublic.Period		Number of current period (1... PeriodCount)	NPER [1]
	VarPublic.YearPeriod		Year of simulation within the current period (1...PeriodLength)	JAHR [1]
	VarPublic.YearBase		Basic year of model	BASJ [1]
	VarPublic.YearCurrent		Current year	
	VarPublic.Month		Current month (1...12) of current year	MON [1]
	VarPublic.Week		Current week (1...52) of current year	
	VarPublic.YearRealisation		Current year within current realization	
	VarPublic.MonthRealisation		Current month within current realization	
	VarPublic.WeekRealisation		Current week within current realization	
Balance profile	VarPublic.Discharge	hm³/Mon	Discharge	X [1,2]

	VarPublic.DischargeProtected	hm³/Mon	Protected discharge	XS [1,2]
	VarPublic.GetDischargeAvailable	hm³/Mon	Smallest free lamella between two balance profiles	FREI [1,7]
	VarPublic.GetDischargeMin	hm³/Mon	Minimum discharge between two balance profiles	MIN_RUNOFF [1,7]
	VarPublic.GetDischargeMax	hm³/Mon	Maximum discharge between two balance profiles	MAX_RUNOFF [1,7]
Sub area discharge	VarPublic.Runoff	hm³/Mon	Natural runoff/ yield	Q [1,2]
	VarPublic.GetRunoffShareRelative		Relative discharge share for a balance profile of a sub area discharge (read)	GET_RELSHARE [1,4]
Universal time series	VarPublic.SeriesGeneral		Value of a universal time series, model dependent	Q [1,2]
User	VarPublic.Withdrawal	hm³/Mon	Withdrawal target	E [1,2]
	VarPublic.ReturnFlow	hm³/Mon	Return flow target	R [1,2]
	VarPublic.WithdrawalBalanced	hm³/Mon	Actual withdrawal	AE [1,2]
	VarPublic.ReturnFlowBalanced	hm³/Mon	Actual return flow/ discharge	AR [1,2]
Reservoir	VarPublic.Capacity	hm³	Reservoir capacity	SK [1,2]
	VarPublic.StorageEffective	hm³	Effective storage capacity	NG [1,2]
	VarPublic.StorageIntermediateLevel	hm³	Subdivision of usable volume at combiniated operation	GR [1,2]
	VarPublic.StorageCurrent	hm³	Storage level during or after calculation in one month	SI [1,2]
	VarPublic.StorageInitial	hm³	Initial storage level in the beginning of a month	SIA [1,2]
Release element	VarPublic.StorageTarget	hm³	Storage level target	G [1,2]
	VarPublic.StorageTargetRelative		Coefficient for calculation of minimum or maximum storage target depending on StorageInitial	BETA [1,2]
Variable parameter	VarPublic.ConstNumber		Freely available numeric parameter	C, CC [1,2]

1) Equivalent in earlier versions

2) Value = Attribute[Key]

4) Value = GetRunoffShareRelative (Key sub area, Key balance profile)

7) Value = Function (Key balance profile 1, Key balance profile 2)

Registration Type 1

Registrations Type 1 serve to establish the frequencies of occurance of certain system states defined in registration terms.

Define the registration **Term** as an arithmetic term (the result is a figure). Position the Registration scale in the range you are interested in.

- Define the registration scale by setting the **Upper** and **Lower bound** plus the number and width of **Steps**. By default the divisioning of the scale is linear; select the option **Logarithmic division** if needed, in this case the upper and lower boundaries must be > 0. The resulting regular scale and the interval distances on the scale is displayed.

- Add **Extra values** that you are interested in to the regular registration scale.

  Add individual value

  Delete individual value.

- Indicate a measure **Unit** for the registration scale.

- Specify the number of **Significant digits** for the registration scale from the interval [2...5].

- Select as needed the output options **Reliability of frequencies** and **Reliability of duration**. Reliability by frequencies results from the ratio of years where the registration quantities' values are reached or exceeded in all time steps (weeks or months) to the total number of simulated years. The reliability by duration results from the ratio of time steps (weeks or months) where the registration quantities' value is reached or exceeded to the total number of simulated time steps.

Registration Type 1

Activate Registration ☑

Name	Discharge at BP 1.4
Term	VarPublic.Discharge**[1.4]**
File	D:\WBalMo4\develop_packages\data_1\Woche\demo4_monat.wbtable
Comment	

Registration Scale

Unit: m³/s

Significant Digits: 5

☑ Reliability on Frequency
☑ Reliability on Duration

Regular Scale

log Logarithmic Division

Upper Boundary	100.0000
Lower Boundary	0.0000
Number of Intervals	10
Width of Intervals	10.0000

```
100.0000
90.0000
80.0000
70.0000
60.0000
```

Extra Values

```
35.0000
```

[Close]

Examples:

- o Current storage volume of Reservoir 27:

  VarPublic.StorageCurrent [27.0].

- o Percentage of demand by User 103.1 covered:

  100 * VarPublic.WithdrawalBalanced [103.1] / VarPublic.Withdrawal [103.1]

Result table (example):

- Registration of discharge at balance profile 1.4

- Term: VarPublic.Discharge[1.4]

- X-axis: 0 – 100 m³/s, subdivided into 10 sections, additionally 35 m³/s as individual value.

- Absolute frequencies are aggregated within the periods set by the model. For the months January through December, the relative frequencies of reaching/ achieving the value calculated in the registration term

are given. In case the simulation time steps were weekly you will find the frequencies of weeks 1 through 52 here. The monthly frequency values given then are generated by aggregation applying the weekly weights.

- Reliability of frequency: the (x-axis) value 60 was reached in 0,5% of all simulated years (i.e. in all time steps of a year) of the first period.

- Reliability of duration: the (x-axis) value 60 was reached in 28,7% of all simulated months of the first period.

X-Axis	Period	January	February	March	April	May	June	July	August	September	October	November	December	Reliability on Freque
100.0000	1	14.2000	27.2000	35.5000	23.5000	7.2000	4.5000	2.0000	0.2000	0.0000	1.7000	8.7000	14.2000	0.0
90.0000	1	19.7000	31.2000	40.2000	27.2000	11.0000	7.5000	4.2000	1.0000	0.0000	4.5000	9.5000	17.7000	0.0
80.0000	1	23.2000	39.0000	45.7000	32.5000	13.7000	11.2000	7.0000	2.5000	0.0000	5.7000	12.0000	22.0000	0.0
70.0000	1	32.0000	47.5000	51.0000	39.7000	19.2000	16.5000	10.5000	5.7000	0.2000	8.0000	16.5000	27.0000	0.0
60.0000	1	40.5000	54.7000	59.5000	45.2000	25.0000	22.2000	16.7000	11.0000	5.0000	11.2000	21.2000	32.0000	0.5
50.0000	1	49.5000	61.7000	68.0000	54.5000	31.5000	28.7000	22.5000	16.0000	11.5000	15.7000	26.2000	38.0000	1.5
40.0000	1	59.7000	71.0000	78.2000	64.2000	39.2000	38.7000	31.2000	22.7000	17.0000	20.5000	32.2000	45.0000	4.0
35.0000	1	96.0000	98.5000	100.0000	99.0000	98.2000	96.2000	94.2000	86.0000	80.7000	76.0000	80.0000	88.0000	59.0
30.0000	1	98.2000	99.2000	100.0000	100.0000	99.2000	97.7000	96.2000	89.5000	83.7000	81.0000	84.7000	94.0000	68.7
20.0000	1	99.7000	100.0000	100.0000	100.0000	100.0000	99.0000	99.0000	93.5000	90.5000	91.5000	97.0000	99.7000	84.0
10.0000	1	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0
0.0000	1	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0

Registration Type 2

Registration tables of **Type 2** serve to record **Event durations**. The result is a table of relative frequencies for the occurance of events of a certain duration.

Define the registration **Term** as a logical term (with "true" or "false" as a result).

Determine the **Registration scale**. If you want the simulation to be executed in monthly steps, the **Upper** and **Lower bounds** can be between 1…12 (months). For models featuring a simulation step length of a week, upper and lower boundaries are between 1…52 (weeks).

Examples:

- o You want the durations of events where a discharge falls short of 1.3 m³/s at Balance profile 1.7 to be registered:

  VarPublic.Discharge [1.7] < 1.3 * 2.628

  Please note that the measure unit for all discharge processes during simulation is hm³/month. Consequently, 1.3 m³/s must be converted: 1.3 * 2.628 * 106 s = 3.42 hm³/month. Certainly you can use this result directly in the term, too: VarPublic.Discharge [1.7] < 3.42

- o You want the frequency, with which the storage volume of Reservoir 1 is found to be in Interval 1 [3.5 hm³ ... 4.0 hm³], to be registered:

  3.5 <= VarPublic.StorageCurrent[1] && VarPublic.StorageCurrent[1] <= 4.0

Result table (example):

- In 0,2 % of all months February of the first period, a time space of 3 months starts during which the registration term is "true".

X-Axis	Period	January	February	March	April	May	June	July	August	September	October	November	December
2	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	2.5000	3.0000	1.5000	0.5000
3	1	0.0000	0.0000	0.0000	0.0000	0.2000	0.2000	0.2000	2.0000	2.2000	2.2000	0.0000	0.5000
4	1	0.0000	0.0000	0.0000	0.0000	0.2000	0.5000	1.0000	1.5000	1.2000	0.0000	0.0000	0.0000
5	1	0.0000	0.0000	0.0000	0.0000	0.2000	0.5000	1.0000	2.0000	0.2000	0.2000	0.0000	0.0000
6	1	0.0000	0.0000	0.0000	0.0000	0.2000	0.2000	0.2000	0.2000	0.0000	0.0000	0.0000	0.0000
7	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.7000	0.5000	0.7000	1.2000	0.2000
3	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	1.0000	0.7000	0.0000	0.2000

- In 1,5 % of all months August of the first period, a time space of 4 months starts during which the registration term is "true".

X-Axis	Period	January	February	March	April	May	June	July	August	September	October	November	December
2	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	2.5000	3.0000	1.5000	0.5000
3	1	0.0000	0.0000	0.0000	0.0000	0.2000	0.2000	0.2000	2.0000	2.2000	2.2000	0.0000	0.5000
4	1	0.0000	0.0000	0.0000	0.0000	0.2000	0.5000	1.0000	1.5000	1.2000	0.0000	0.0000	0.0000
5	1	0.0000	0.0000	0.0000	0.0000	0.2000	0.5000	1.0000	2.0000	0.2000	0.2000	0.0000	0.0000
6	1	0.0000	0.0000	0.0000	0.0000	0.2000	0.2000	0.2000	0.2000	0.0000	0.0000	0.0000	0.0000
7	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.7000	0.5000	0.7000	1.2000	0.2000
3	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	1.0000	0.7000	0.0000	0.2000

Registration Type 3

Registrations Type 3 allow you to record mean values, as well as standard deviations, minima, and maxima.

Specify the registration **Term** as an arithmetic term (the result is a figure). Select your desired measure **Unit** and number of **significant digits**.

You can have mean values, standard deviations, minima, and maxima registered. The output of mean values is mandatory.

The determined **Registration scale** is valid for all Registrations Type 3 in this model. You access the registration scale by clicking on the arrow symbol.

With the **Registration scale** you fix the intervals of aggregation

for establishing mean values etc. You can also indicate individual years or time spaces within the balance horizon. The latter are allowed to coincide with the model's period boundaries.

Result table (example):

- Outputs are mean value, standard deviation, minimum, and maximum in the interval between upper and lower boundaries of the value described by the registration term per month.

Type	Column	Meaning
Mean	January – December	Monthly mean values
	Mean	Yearly mean value
	Smallest mean	Mean smallest monthly value
		This value is calculated by establishing the smallest monthly value in each simulated year within the interval. Then the mean of the total of smallest monthly values is established.
Standard deviation	January – December	Standard deviations of monthly means
	Mean	Standard deviations of yearly means
Minimum	January – December	Smallest monthly values
	Mean	Smallest yearly mean
Maximum	January – December	Largest monthly values
	Mean	Largest yearly mean

Lower Boundary	Upper Boundary	Type	January	February	March	April	May	June	July	August	September	October	November	December	Average Value	Lowest Avera
1999	2002	Mean Value	143.0000	152.0000	164.0000	190.0000	198.0000	187.0000	168.0000	143.0000	123.0000	112.0000	114.0000	126.0000	152.0000	
2003	2006	Mean Value	155.0000	155.0000	165.0000	186.0000	197.0000	194.0000	186.0000	175.0000	164.0000	160.0000	160.0000	165.0000	172.0000	
2007	2010	Mean Value	173.0000	165.0000	169.0000	191.0000	202.0000	199.0000	190.0000	178.0000	168.0000	166.0000	168.0000	171.0000	178.0000	
1999	2002	Standard Deviation	67.2000	49.8000	38.1000	40.3000	56.1000	68.0000	79.7000	88.1000	91.6000	95.9000	94.0000	88.9000	54.5000	
2003	2006	Standard Deviation	63.7000	46.9000	37.5000	41.4000	52.5000	53.1000	54.4000	57.8000	62.2000	70.6000	72.0000	69.8000	47.6000	
2007	2010	Standard Deviation	47.9000	37.9000	31.9000	38.5000	49.6000	51.3000	52.6000	55.2000	56.0000	59.6000	62.9000	61.1000	42.4000	
1999	2002	Minimum	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	17.0000	
2003	2006	Minimum	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	
2007	2010	Minimum	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	11.1000	
1999	2002	Maximum	200.0000	180.0000	180.0000	210.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	230.0000	220.0000	222.0000	
2003	2006	Maximum	200.0000	180.0000	180.0000	210.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	230.0000	220.0000	222.0000	
2007	2010	Maximum	200.0000	180.0000	180.0000	210.0000	240.0000	240.0000	240.0000	240.0000	240.0000	240.0000	230.0000	220.0000	222.0000	

Registration Type 4

Registrations Type 4 allow the output of several system states as a time series. Using a logical term, you can filter the output und by assigning **Ranking numbers**, you sort the registration into the ranking list.

Define a logical term (the result is "true" or "false") as the filter. If the result is "true", the output occurs in the current time step.

Determine the columns for the output data in the results table on the **Columns** tab:

- Indicate the column **Title**, an arithmetic **Term** (the result of which is a figure) and the measure **Unit** and number of **Significant digits**.

Assign a ranking number for the registration on the **Rank** tab.

Result table (example):

- For each time step, all values determined in the **Registration Type 4** are issued in the positions according to their ranking numbers in the ranking list. The time step is described by indicating year, month, and week. Apart from this, the period of the time step and the realizations of the model run are given.

- In the data columns you find the values for the according registration term. You are shown the registration term, measure unit, and comment in the data column by the meta-data. Activate a cell you are interested in in the column.

- You can view the registration's ranking number and the (limiting) term in the registration table's meta-data.

Realisation	Period	Year	Month	Week	si1	si2	ng1	ng2	x1	x11	x111	x13	x
8	1	2000	3	9	180,0000	0,0000	180,0000	0,0000	18,0090	20,0100	20,0100	71,9780	
8	1	2000	4	13	180,0000	0,0000	210,0000	0,0000	8,8290	9,8100	9,8100	52,8680	
8	1	2000	5	18	207,6500	0,0000	240,0000	0,0000	7,3350	8,1500	8,1500	35,5850	
8	1	2000	6	22	187,9700	0,0000	240,0000	0,0000	15,2730	16,9700	16,9700	46,7120	
8	1	2000	7	26	197,9300	0,0000	240,0000	0,0000	3,3300	3,7000	3,7000	26,2900	
8	1	2000	8	31	153,8500	0,0000	240,0000	0,0000	4,0770	4,5300	4,5300	28,1100	
8	1	2000	9	35	115,0100	0,0000	240,0000	0,0000	3,1950	3,5500	3,5500	22,6400	
8	1	2000	10	40	59,2800	0,0000	240,0000	0,0000	4,6530	5,1700	5,1700	24,3530	
8	1	2000	11	44	10,0000	0,0000	230,0000	0,0000	11,3670	12,6300	12,6300	44,8620	
8	1	2000	12	48	20,3300	0,0000	220,0000	0,0000	26,4870	29,4300	29,4300	70,6870	
8	1	2001	1	1	92,8120	0,0000	200,0000	0,0000	7,7850	8,6500	8,6500	46,2050	
8	1	2001	2	5	98,8330	0,0000	180,0000	0,0000	14,4360	16,0400	16,0400	56,8770	
8	1	2001	3	9	138,5200	0,0000	180,0000	0,0000	10,8630	12,0700	12,0700	45,8420	
8	1	2001	4	13	150,0600	0,0000	210,0000	0,0000	21,0870	23,4300	23,4300	62,9700	
8	1	2001	5	18	201,7300	0,0000	240,0000	0,0000	6,2100	6,9000	6,9000	35,5680	

Column
Period

Meta Data
| Physical Name | nper |
| Data Type | Int32 |

Filter
☐ Advanced Mode
Period =

Sorting

Registration Type 5
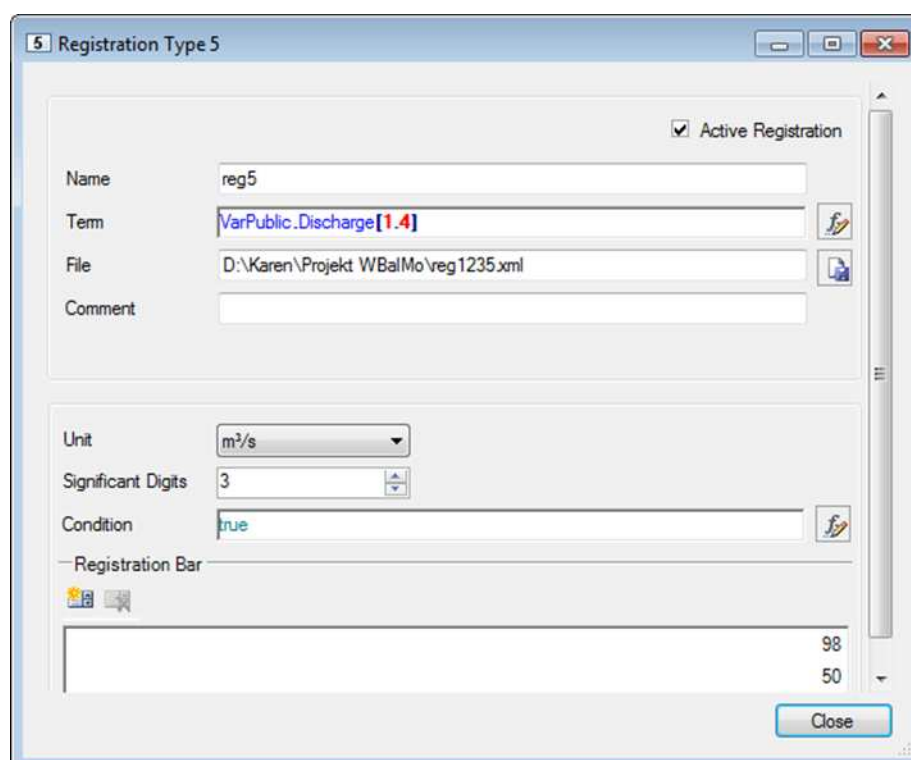
The result of **Registration Type 5** is a table of system states which occur with a specific frequency. The universal data set per time step can be limited using a logical term.

Specify the registration Term as an arithmetic term (the result is a figure).

Select the measure **Unit** and number of **Significant digits**.

Define a logical term (the result is "true" or "false") as a **Condition**. If the result is "true", the value is incorporated in the calculation.

Indicate the percentiles you are interested in inside the interval [1...99] as the **Registration scale**.

Result table (example):

- In the columns January to December you find the values for the preset term which correspond to the percentiles.
- You find the values' registration term and measure unit in the table meta-data.

Percentile	January	February	March	April	May	June	July	August	September	October	November	December
98	33,9000	35,0000	35,0000	35,0000	35,0000	35,0000	28,4000	16,7000	15,3000	17,3000	20,1000	24,0000
50	48,6000	62,2000	71,6000	53,0000	35,0000	35,0000	35,0000	35,0000	35,0000	35,0000	35,0000	35,0000

Working with Model Data

Comparing Two Models
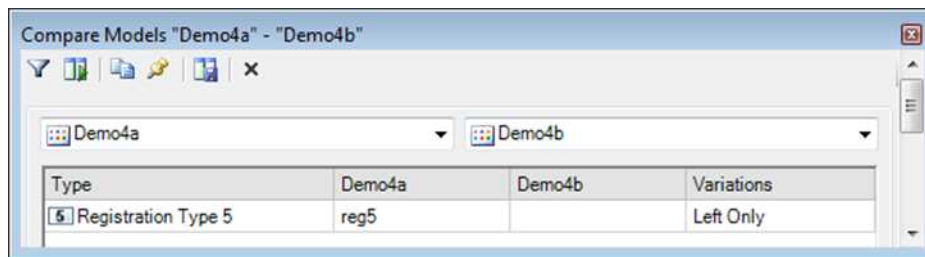
Two models can be compared within a project. Comparison of individual model elements is performed in two steps:

1. Occurrence of objects with the same **primary attribute** (usually key, otherwise name) in both models,

2. Comparison of all **data** assigned to the element. Any difference found (even a space in the text) is marked as a difference in the element.

You can limit data comparison to the data groups you are interested in by using the filter function.

	Filter
	Compare models
	Copy
	Mark object
	Display differences as report
	Close

- Open the model comparison window by menu **Project | Compare models**.

- Select from the dropdown lists showing the models of the current project the **two models** you want to compare (perform a data check on the models and correct possible errors beforehand as faulty models will not be compared!).

- Open the **Filter** dialog by the according button and set those data groups you want to study active. With buttons   you can activate or deactivate all data groups at a time.

- **Compare models**: the comparison table displays the examined data types, the names of the compared result tables, and the differences found, if any.

- Elements that differ in both models are marked in the navigator with **Mark object**. The elements thus marked can be called up and edited in the **Marked objects** window (**Data** menu).

- **Copy** copies all of the rows of the comparison table to the Windows clipboard. Subsequently you can paste the table contents e.g. as tab-separated text into an Excel table. To copy individual rows, use the Windows clipboard in the known manner.

- To view more details on the differences or edit them as needed, you can activate the **objects** of a model by double-clicking the cells in columns 2 or 3.

- When you click the tool **Display differences as report**, the comparison will be generated as a report that can be stored. Customize the view by expanding or collapsing the nodes

  o The **status bar** at the bottom left indicates the number of differences found.

  o If required, save the **report** of the model comparison as an HTML file at a location of your choice. Use the **Save as…** icon in the **Report: Compare models mask.**
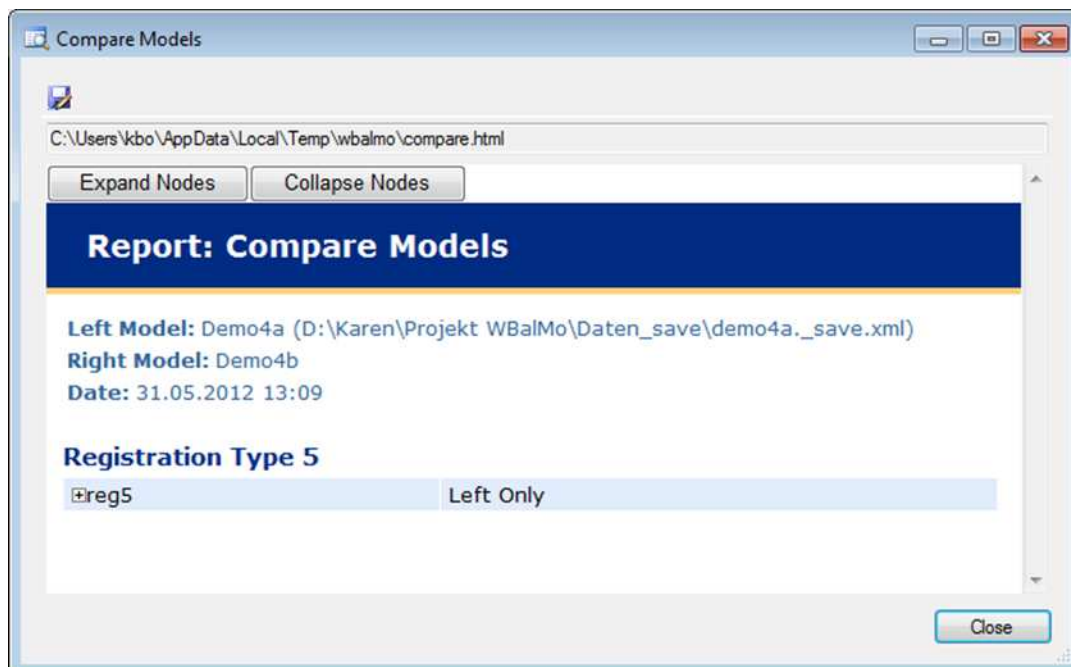
Data Check and Error List

To guarantee that simulation runs are initialized flawlessly und to minimize potential runtime errors during calculation you can execute a data **Check** for all model elements and for the model itself.

A completed data check and a model found flawless are prerequisites for the simulation to run stable. You can skip the data check immediately preceding the simulation run by activating the option Allow simulation run of unchecked model in the menu path **Model | Model properties | Data**. This is advisable if, in a validated model, you have for example changed individual numerical values, or made small modifications within DYN elements (and thus not affecting the model data that is to be checked).

Check data in the whole model:

- The sub menu **Model | Check** gives you the following options:

    Execute data check: all data in the model are checked.

    Error list indicates the faulty files. Double clicking gives you a description of the error.

    Report errors generates a detailed error report.
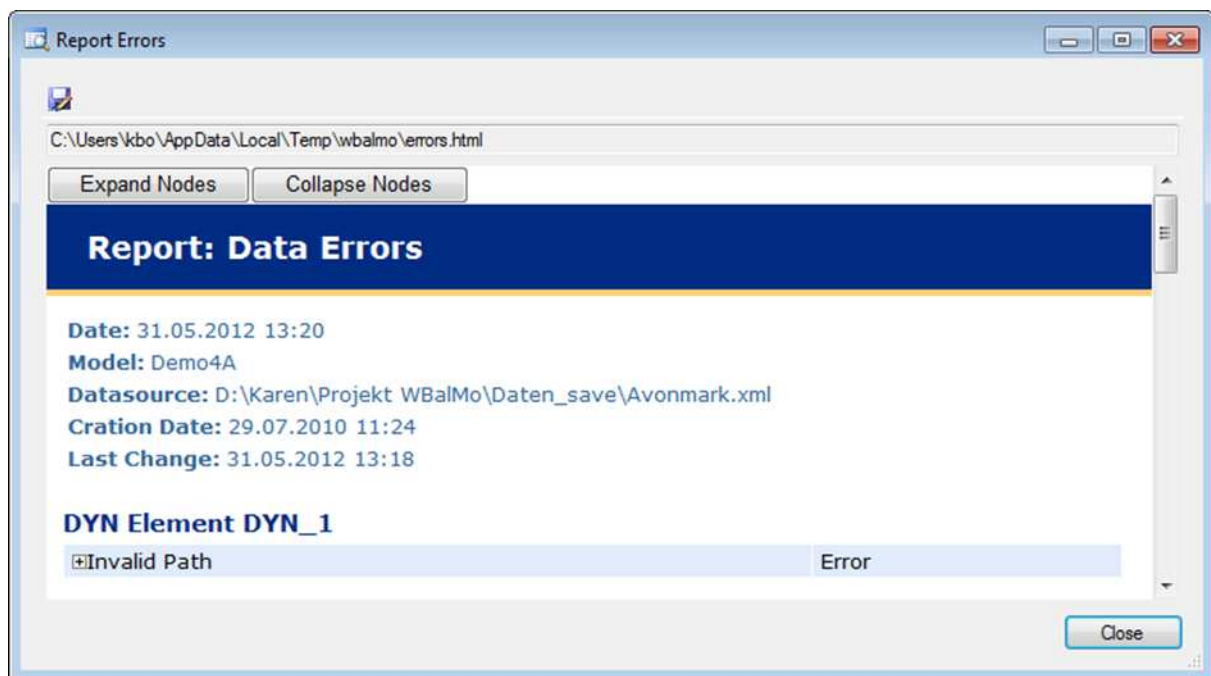
The menu item **Data | Reset check state** resets the status of checked data to "unchecked".

Data that have been checked and found flawed are highlighted red in the navigator

Check data of selected model elements:

You can also check model elements individually, e.g. after you have first added them to the model or edited them and want to save yourself a re-check of already checked data. For this, click the button **Check** on the first toolbar while your object is activated.

Check: the active object is checked

Execute check: the model and all its objects are checked.

As an important part of this module, the program variables used in DYN elements and registrations are checked. In case any keys are no longer available after the DYN texts and registration terms they were used in have been correctly filed, either because they were re-named or because the model object was deleted, this is reported as an error.

It is also checked

- that at least one sub area discharge or one universal time series is defined,

- if files of discharges/ long term series exist in the indicated directories for all sub area discharges. The data series are further read in and checked against the number of realizations set for simulation in the model.

- where found, any discrepancies are displayed as messages.

To view and correct the data, activate the faulty model object by double-clicking the corresponding row.

Example 1: Error list
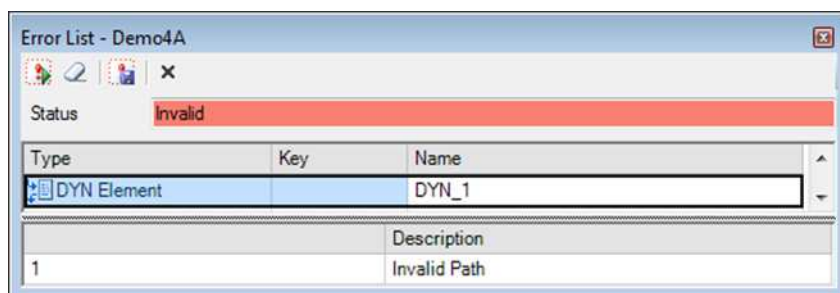
Example 2: Model is faultless
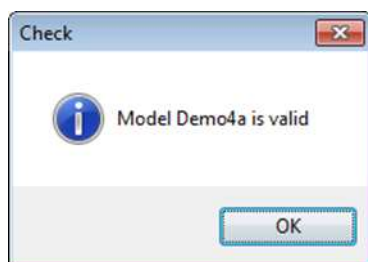
Report

Menu item **Model | Report** gives you access to reports on each individual model object. They contain information on all settings made in the model. You can either activate the model elements individually by setting checkmarks behind them, or activate or deactivate them all at once using the according buttons.
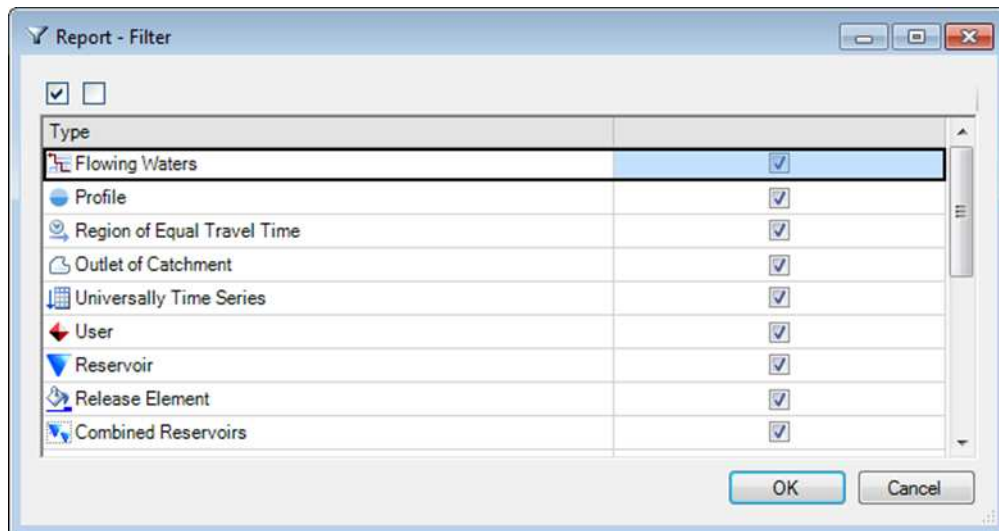
To make your work easier, use the buttons to select one of the following options:

Activate all activates all existing registrations

Deactivate all sets all existing registrations inaktive.

After confirming with **OK** reports are generated for all activated elements reflecting all data contained in the model. By clicking the plus or minus sign in front of the data group you can expand or collapse the nodes in the view, respectively.
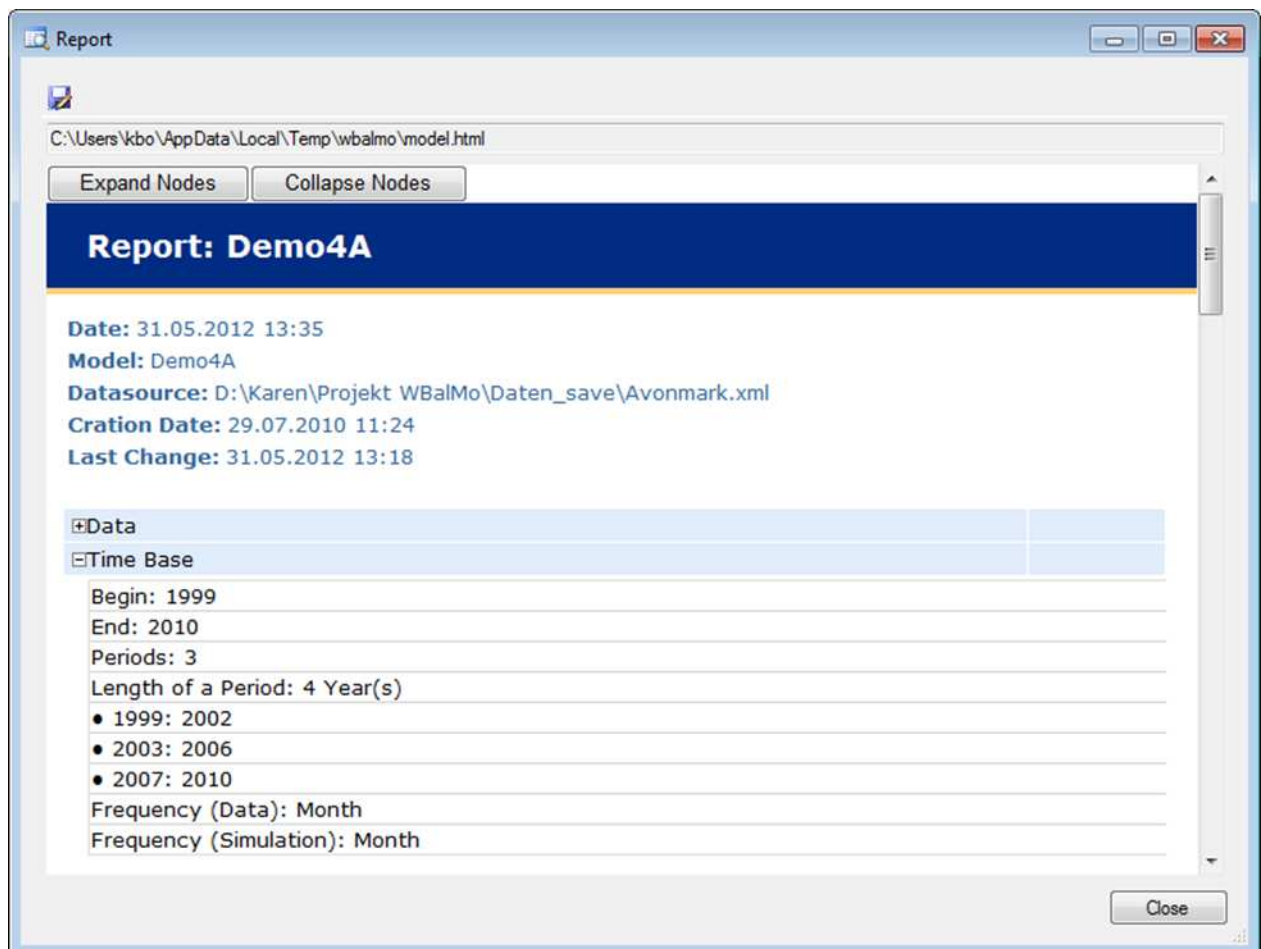
Reports can be issued for all following objects:

- Data

- Time basis

- Release element

- Profile

- DYN element

- River

- Constant (double)

- Unit

- User

- Registrations Types 1, 2, 3, 4, 5

- Reservoir

- Sub area discharge

- Tracker.
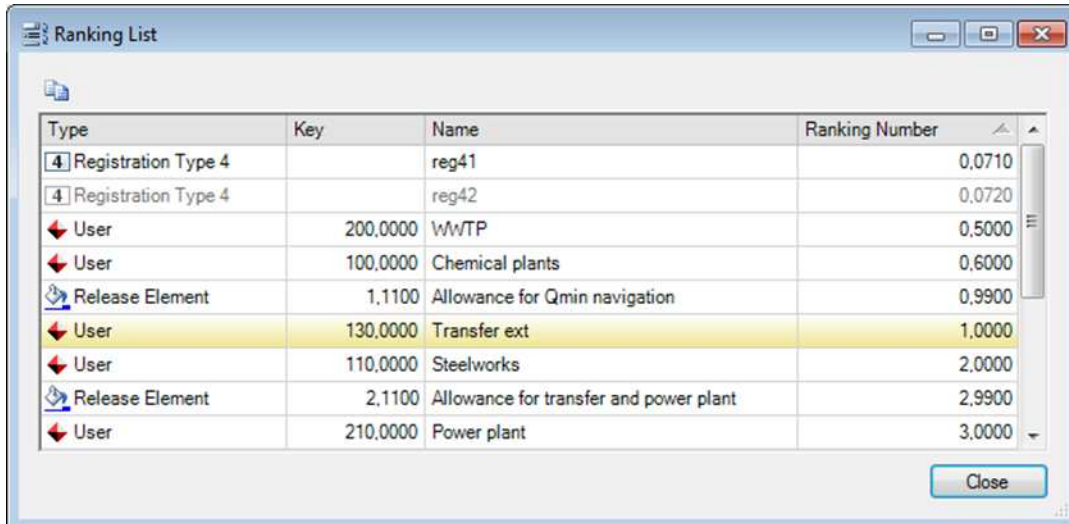
Ranking List

The **Ranking list** is a table with columns containing details of all ranked elements in the current model. The ranking list is processed by balancing or executing the model objects, respectively, in each time step.

- You find all ranked model elements again as **Types**: users, release elements, DYN elements and Registrations Type 4

- **Key**

- **Name**

- **Ranking number.**

The following menu path takes you to the item **Ranking list**:

- View the list in **Data | Ranking** list.
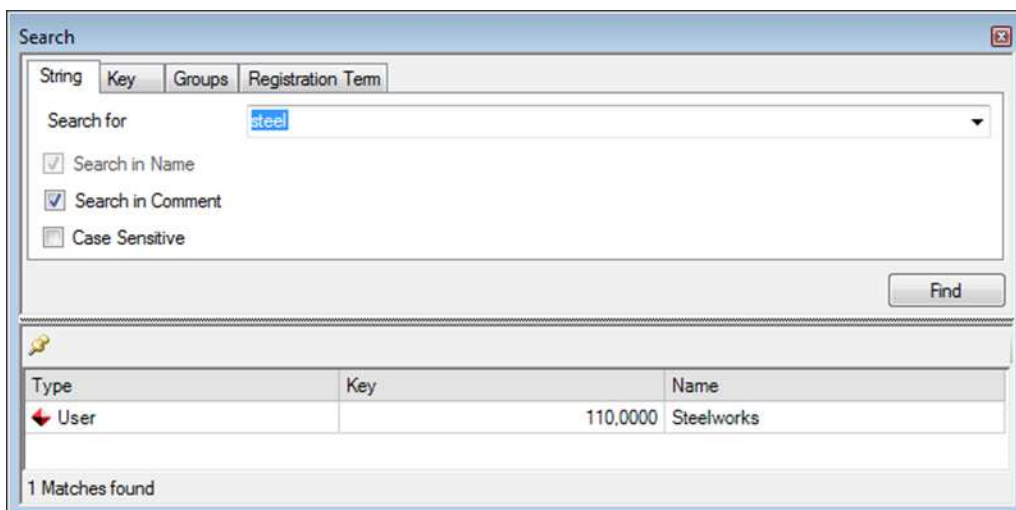
Copy allows you to copy the text in the marked rows.

By double clicking on a table row, you can activate the corresponding model object, view data or change the ranking number, if needed.

Search

WBalMo offers a search function that you can also use for navigation. Follow the menu path **Data | Search.** Select your desired model elements in the **String, Key, Groups,** or **Registration** term by the corresponding criteria in your active model's properties. Criteria can be e.g. a key word in a comment, a section inside a key field, the shortname, or the formula used in a registration.
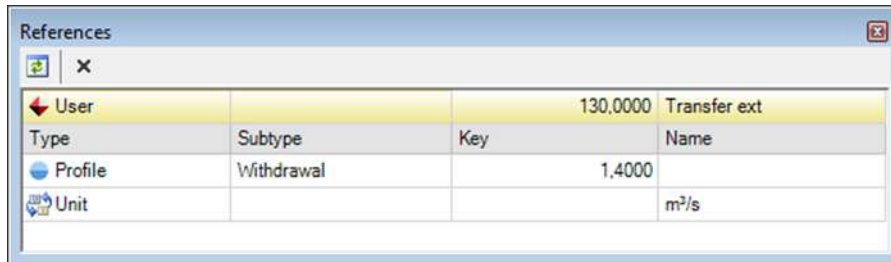
Apart from activating them by double-clicking, you can also bookmark the objects you have found. This highlights them in the navigator and they are displayed in the **Marked objects** window.

Viewing References to Other Objects

If you want to check the other data an object is linked to, activate this object and follow the menu path **Data | References**. Call up the references belonging to the active element by clicking the **Refresh** button.

Via double click you can activate and view the reference objects.

Marking Data

If in a **WBalMo** session you want to set focus on a selection of the model data, you can bookmark these objects. **Marked objects** are highlighted in the navigator and displayed in the window Marked objects. You can also zoom into the marked objects in the system sketch.

Marking objects:
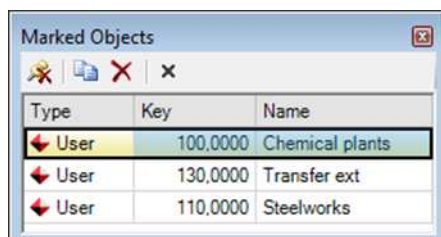
Activate an object by clicking on it in the navigator. In case you want to mark several objects, keep the control key pressed while clicking. Then set a bookmark in the menu **Edit | Mark object** or via the **Mark object** button .

Marked objects appear yellow.

- Model elements can also be selected graphically and then marked in the system sketch.

In the **Data | Marked objects** menu the marked objects are displayed in a list.

- Employ this tool to navigate to the marked objects by double-clicking.

- If needed, you can **Remove** the mark.

- The option **Delete** ✗ removes the element from the model.

Remove marks:

- The menu function **Data | Select none** removes all bookmarks in the model.

- Remove the mark from an individual object by activating the object in the **Data | Marked objects** menu and subsequently clicking the **Select none** ✗ button.

File References to Data Sources of Time Series

The menu **Data | Data sources of series** gives you an overview of the time series files existing in the model including sub area discharges. Data type, key, name and file name of the time series are all listed. You can manage the files in the explorer using a browser function.
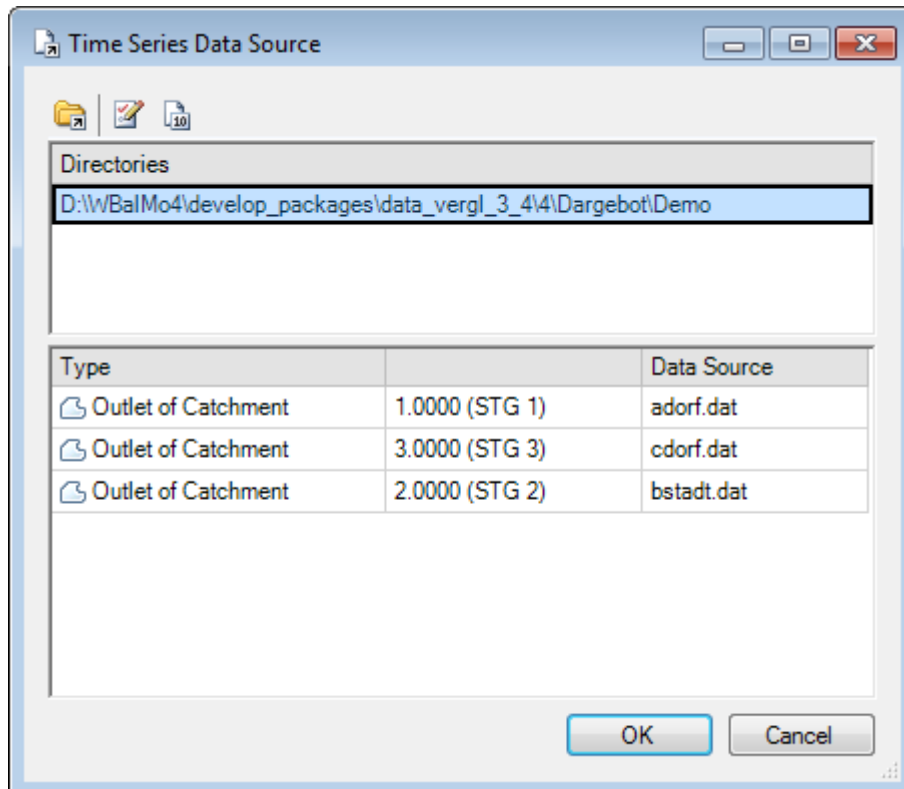
- Change or update the directories for data series.

- Inform yourself about the maximum number of realizations possible for your data.

File References to DYN Element Libraries

In the menu **Data | Associated files of DYN elements** you find information on the DLL files the DYN element libraries consist of.

In the upper part of the table (1) you find all libraries (.DLL) used in your model. In the lower table (2) all DYN elements belonging to the library marked in (1) are listed.

- **Assign file** opens the explorer at the location of the DYN element library. The browser function gives you access to the files in the explorer, and you can manage them here.

- The **File properties** window opens the tabs **File** and **Interfaces** which contain informationen on the file properties of the marked DYN element library, or the expoted functions, respectively. If the file is not available in the specified spot, this button is gray.
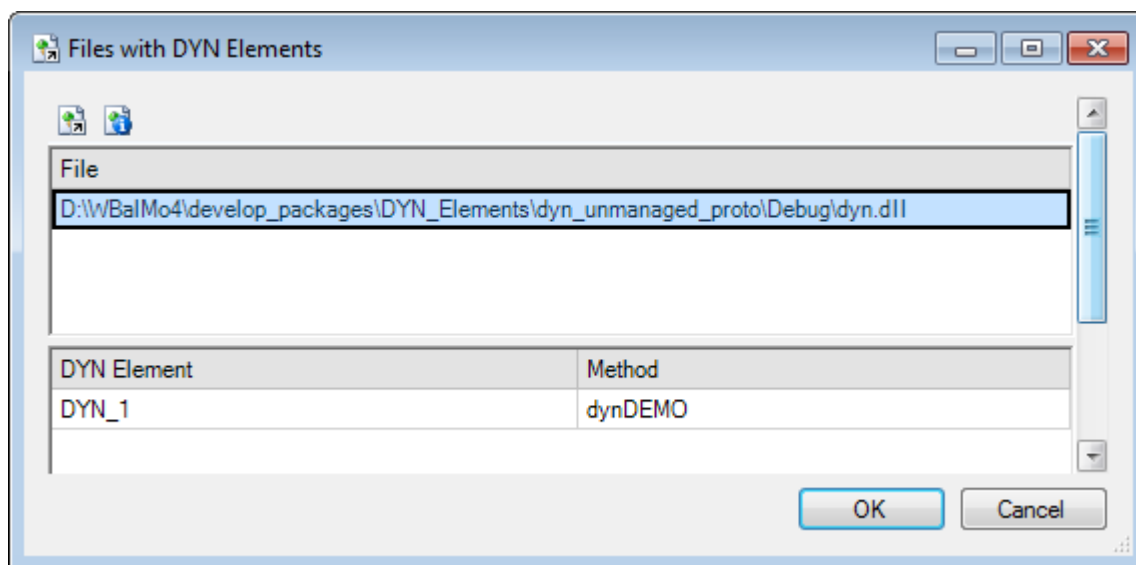
DYN element, **File** tab
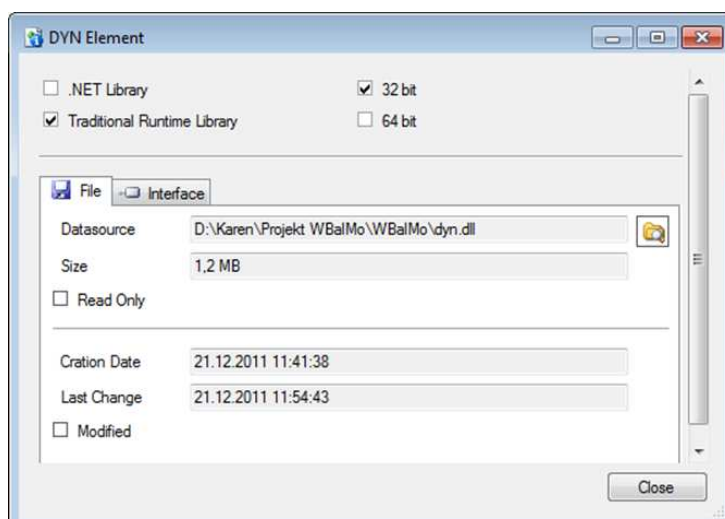
DYN element, **Interface** tab
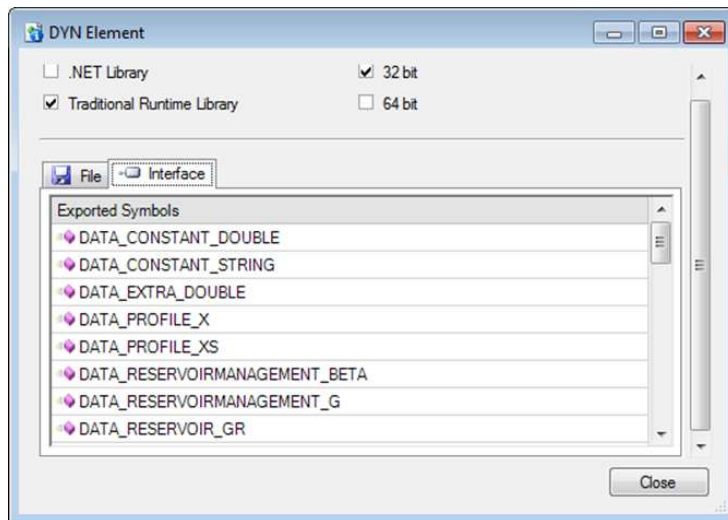
Extended System Variable

Inside a model you have the option of extending selected data groups by a variable of your choice, in order to then use them in DYN elements and registration terms. The purpose is not only to implement model specific algorithms more efficiently in DYN elements but also to improve the readability of registration terms in the results file. **WBalMo** standard data of objects belonging to the data groups are accessed using keys.

Extended system variables can be defined for the following data groups:

- Profile
- Sub area discharge
- Universal time series
- User
- Reservoir.

Creating an extended system variable::

- The menu **Data** | **Extended system variable** opens the corresponding window. Click the **Add** button and enter Name and Comment for your system variable. Wählen Sie den Typ aus der Klappliste aus.

Deleting an extended system variable:

- Activate the row and click the **Delete** icon. ✕
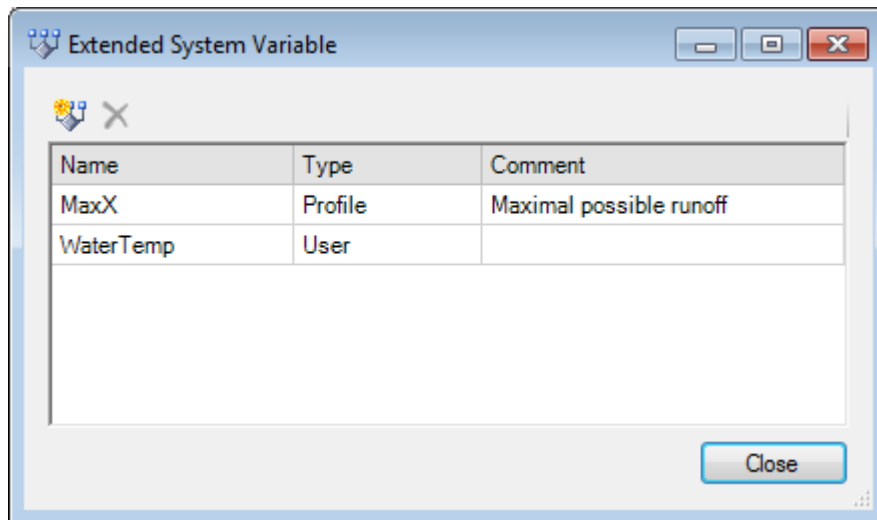
Examples for access to an extended system variable:

- FORTRAN: Staubereich(NUTZER_ID(233.7)).
- C# and registration term:
  VarPublic.Extra["Staubereich"][233.7]

Examples how to use extended system variables:

- Extended quantity model: Reservoir areas to calculate evaporation.
- Hydraulic model: Extension of balance profile data by river bed depth and maximum possible limiting discharge.
- Model for landscape water balance: Extension of data on all users by groundwater isobath data and/ or a complex structure „Staubereich/ Reservoir area".
- Water quality model: Eutrophication of stagnant water bodies.

OpenMI

WBalMo features a configurable OpenMI interface and can be coupled with other OpenMI-compatible models.

Public data in a **WBalMo** model:

- All information about the model's time structure and the current time step are provided as OutputExchangeItems (read-parameters).
- Additionally you can define other OutputExchangeItems as well as InputExchangeItems (the value may be written by an external model) for your model by making objects public. For these objects all features indicated in the table are available at the interface.

- For this, open the according dialog in menu **Data | OpenMI** and activate the tab **Data**.

- Select the data group of your choice using the buttons ⬤ ⬠ ⎗ ◄ ▼ ⬟ ⅭⅢ and activate the checkboxes **OutputExchangeItem** and/ or **InputExchangeItem** for the model objects you have made public.
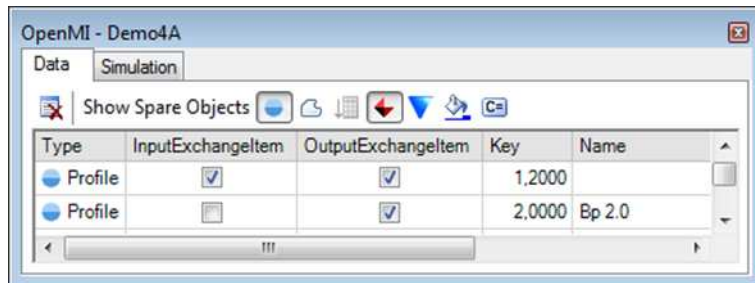
Data type	Variable	Measure unit	Meaning
Time step	RealisationCount		Number of realizations
	Realisation		Number of current realization (1... RealisationCount)
	PeriodCount		Number of periods
	PeriodLength		Length of a period in years
	Period		Number of current period (1... PeriodCount)
	YearPeriod		Simulation year within the current period (1...PeriodLength)
	YearBase		Basic year of model
	YearCurrent		Current year
	Month		Current month (1...12) of current year
	Week		Current week (1...52) of current year
	YearRealisation		Current year within current realization
	MonthRealisation		Current month within current realization
	WeekRealisation		Current week within current realization
Balance profile	Discharge	hm³/Mon	Discharge
	DischargeProtected	hm³/Mon	Protected discharge
Sub area discharge	Runoff	hm³/Mon	Sub area discharge
Universal time series	SeriesGeneral		Values of a universal time series, model dependant
User	Withdrawal	hm³/Mon	Withdrawal target
	ReturnFlow	hm³/Mon	Return flow target
	WithdrawalBalanced	hm³/Mon	Actual withdrawal
	ReturnFlowBalanced	hm³/Mon	Actual return flow/ discharge
Reservoir	Capacity	hm³	Reservoir capacity

	StorageEffective	hm³	Effective storage capacity
	StorageIntermediateLevel	hm³	Subdivision of usable volume at combined operation
	StorageCurrent	hm³	Storage level before or after calculation in one month
	StorageInitial	hm³	Initial storage level in the beginning of a month
Release element	StorageTarget	hm³	Storage level target (minimum or maximum)
	StorageTargetRelative		Coefficient for calculation of minimum or maximum storage target depending on StorageInitial
Variable Parameter	ConstNumber		Freely available numeric parameter

Creating an OpenMI model file:

- Activate the **Simulation** tab in the **OpenMI** dialog.

- Click the **Create model file** button and define location and file name. This .OMI-Datei importantly contains the description of the **WBalMo**LinkableEngine class which implements LinkableEngine, as well as the model file path. Informations on publicized model objects are not part of this file.

Managing OpenMI-projects:

- Create an OpenMI-project (.OPR-Datei) outside of **WBalMo** using the **OpenMI Configurator**. This project contains all OpenMI-compatible models encompassing the network as well as at least one trigger driving the model network. The OpenMI Configurator is part of the OpenMIdeveloping package.

- Activate the **Simulation** tab in the **OpenMI** dialog.

- Assign one or more OpenMI projects to the model.

- Start the simulation of a composition directly from **WBalMo** . Please remember to save the model prior to simulation.

- During simulation, the outputs from the OpenMI-project are redirected to a console (**Menu | Window | Console**). Here you can inform yourself about the status of the simulation and any occurring errors.
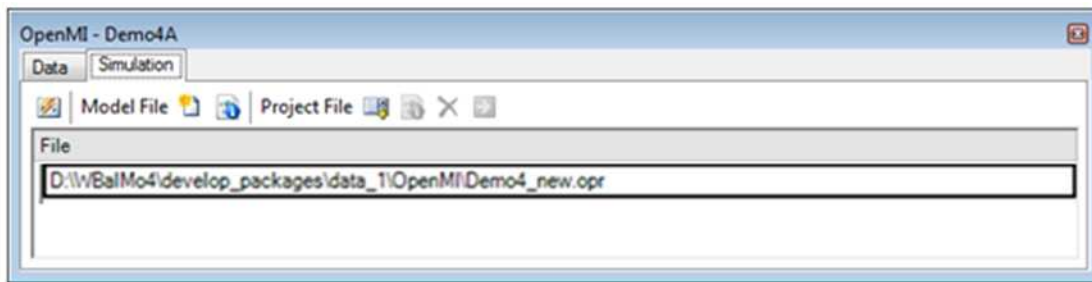
Activating/ Deactivating Registrations

Registrations are table definitions for result data and enable statistical evaluations of simulation results. Within one model it is possible to define a multitude of registrations.

Especially when several persons working with a model with different focuses want to evaluate their results, evaluation can be made much more efficiently by specifically displaying or hiding registration. Another example were this would make sense is after models have underwent modifications of a larger extent (or have been re-established), where first registrations offer at least rough indication for a model's plausibility but no other registrations need to be deleted. Registration can be selectively activated or deactivated depending on the model states you want to examine closer.

- Existing registrations can be activated, or deactivated using the menu path **Data | Activate/ Deactivate registrations**, and bei double-clicking a registration of your choice or clicking the **Show registrations** icon, they can also be edited.
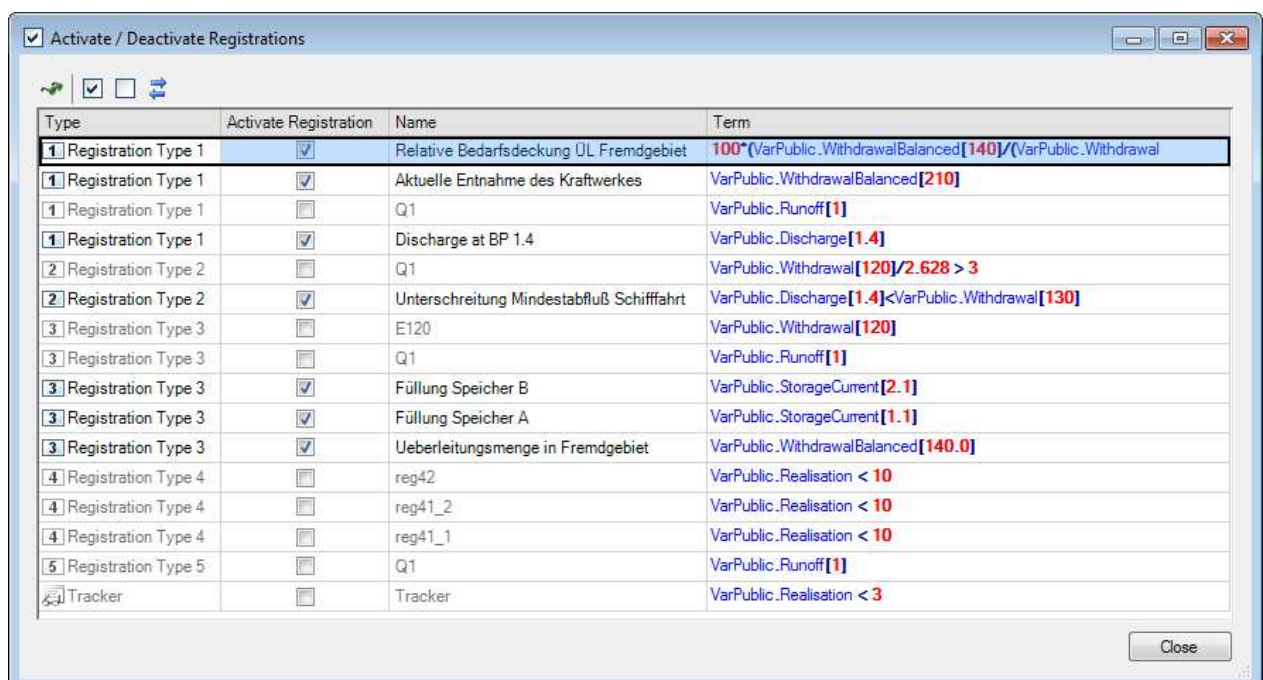
Show registrations opens the registration's data sheet

Activate all activates all existing

registrations

☐ **Deactivate all** sets all existing
registrations inactive

⇄ **Switch activations** switches the
activation status to the contrary.

Simulation Process

Properties and File References

In the **Model | Simulation** menu item you can determine the simulation properties, start
the simulation, and manage and view the corresponding files.

- **Properties** tab

  o First determine the **Frequency** you want for the
  simulation in the dropdown list. Specify the number of
  Realizations depending on the time series applied for
  the sub area discharges and general time serie.

  o [icon] If required you can **Configure the tracker**

  o Update the comment before starting the simulation. The
  first 4000 characters in the comment are included in the
  results file.
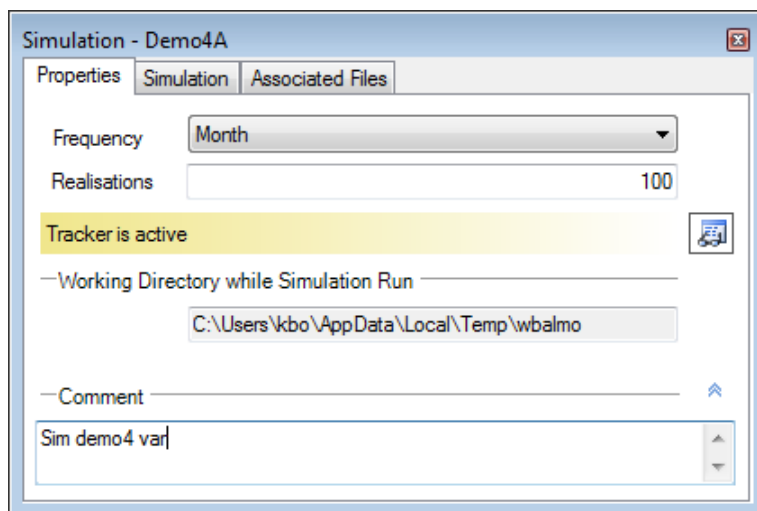
- Use the icons on the **Simulation** tab to initiate a data
  check on the models and to start and stop the
  simulation. Below you can follow the simulation progress
  after initialization.
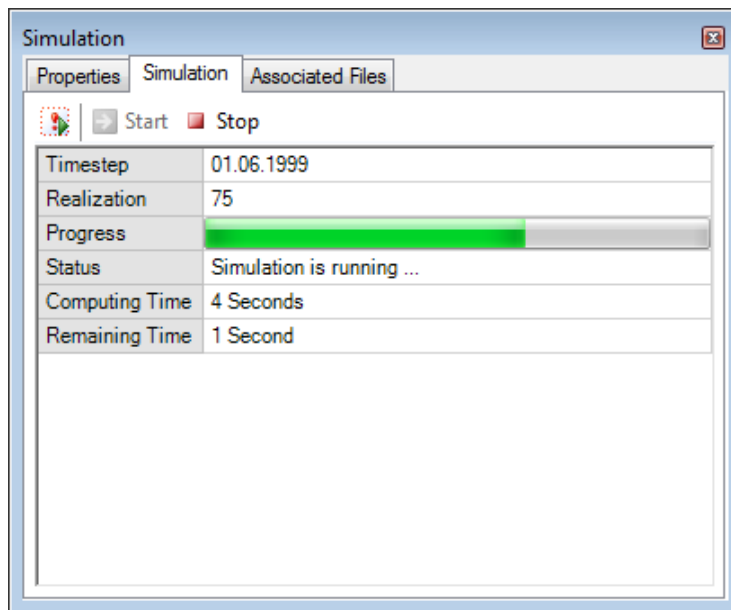
- The **Files** tab lists the results files for the registration tables and time series outputs connected to the model. Additionally you can access the simulation's working directory from here, which possibly also contains specific output files from DYN elements etc. Manage and edit the files using the icons if necessary:

	Refresh
	Open directory in the explorer
	Open
	Delete

In the menu item **Model | Model properties** on the **Simulation** tab you find a reduced selection of the functions described above**.**
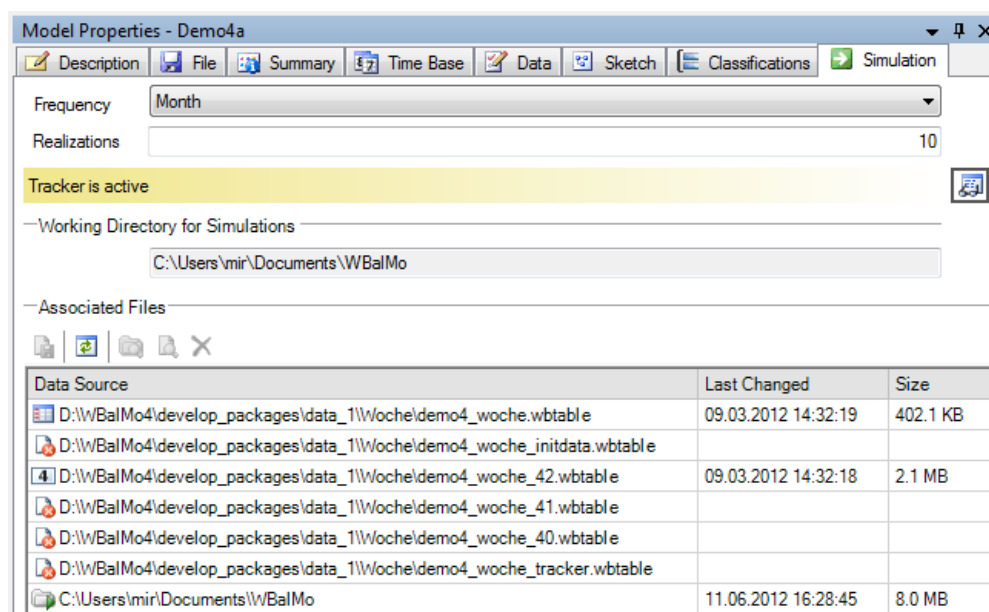
Starting the Calculation

In the **Model | Simulation** menu item you can determine the simulation features, start the simulation, and manage and view the corresponding files.

To start, activate the **Simulation** tab.

- o Before starting the simulation, a data check is required.
- o Start the simulation. In the table below you are informed about the status of the calculation.
- o You can stop the simulation. Please consider that in this case the results files are not completed correctly and are thus defective.
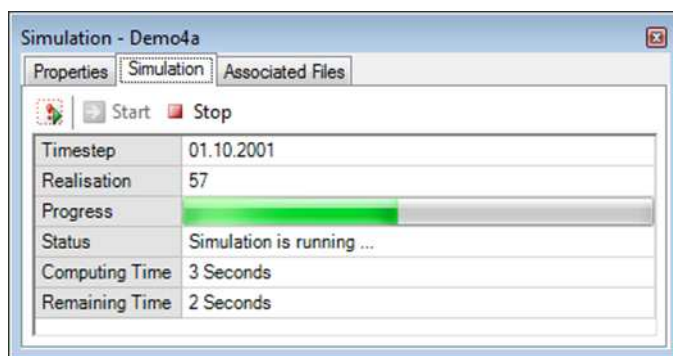
Note:

You can skip the data check prior to the simulation run activating the option **Allow simulation run of unchecked model** in the menu item **Model | Model properties | Data**. It is recommended to **Automatically save the model** before running a simulation. You find this option in the menu path **Model | Model properties | File**.

Result Files

All **Result files** are saved as XML data bases after a simulation is completed. The file extension is .xml.

Open the results files belonging to a model (Files with Registration 1, 2, 3 and 5; Files with **Registration Type 4**; tracker) by menu path **Model | Simulation** in the **Associated files** tab.

Independently of the model, you open the **WBalMo** results via Model | Result file.

Opening results files:

- • Indicate the result file's location in the browser on the **Data source** tab.

     Open directory in the explorer

     Refresh

Open.

- You can leave the dialog open when you restart the simulation. After the simulation ist completed, refresh the results file manually with the refresh .

- The tab **Data source** contains information on the file properties location, size, write-protection status, and dates of creation and last modification. In the meta-data **Table** you find entries for names and comment (if any) of the associated model, as well as for the defined interval, the number of realizations carried out, and number of tables contained in this results filet.
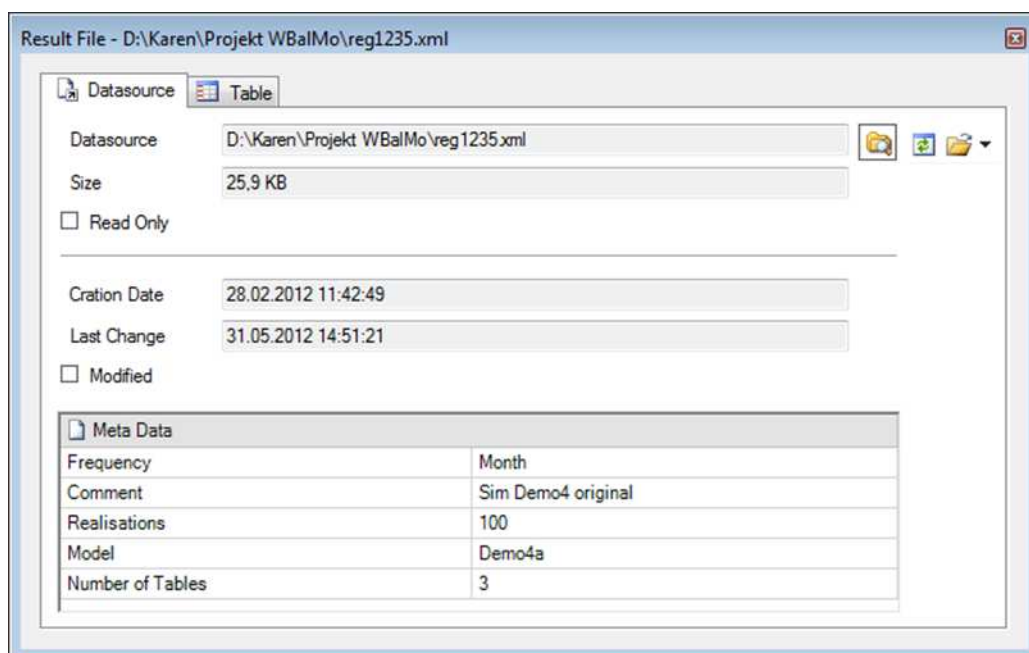
Display table:

- Chose a registration table from the dropdown list on the **Table** tab.

- The following meta-data are shown for the selected registration table: type of registration, name and comment (if any), and the registration term.

Table columns and filter:

- Select a column from the dropdown list. Alternatively you can mark a cell in the table, thus activating the corresponding column.

- An array of meta-data are displayed along with the selected column. Next to physical column name and data type, registration term and comment are important for Registrations Type 4 and the tracker.

- If required, the table data can be filtered. In **Filter**, select one of the criteria offered in the dropdown list and confirm with [filter icon]. As a prerequisite to set a filter, the selected column must feature an integer data type.

- In the **Advanced mode** you can individually set terms for the filter. For this you can combine columns or use relational operators. The limitation to integer data types in the columns is canceled. Example: "Period=3" and "September>2"

- After selecting a column from the dropdown list, you can sort the table corresponding to the values in the column an ascending or descending order.

Tables:

[copy icon] **Copy content** copies the contents of marked cells into the clipboard as a text

	Save as … saves the entire table. You can then open this file in MS Excel or Access and continue editing it
	Analysis of selected cells delivers number, maximum, minimum, and sum of the marked values.

Find information on the contents of registration tables in the following sections of **Registration Type 1**, **Registration Type 2**, **Registration Type 3**, **Registration Type 4** and **Registration Type 5**.

Σ Analysis of Selected Cells	
Count	112
Mean Value	21,0000
Sum	2352,0000
Minimum	0,0000
Maximum	100,0000

Comparing Two Result Files

By comparing result files you can directly compare the effects of different management strategies.

Open files and select registration tables:

- Open two result files via menu item **Model | Compare result tables** as described there. File properties and meta-information provide information on properties of the underlying models, simulation runs, and registrations.

- Then activate the registration tables you want to compare in the **Table** tabs.

Run comparison:

- Set a **tolerance limit**, defining from which difference on the contents of cells should be marked as different.

  | Tolerance ≤ | 0,0001 |

- Start the **Comparison** . Cells with different contents are marked. You can remove this mark by applying **Reset view** . You are informed about the number of differences found.
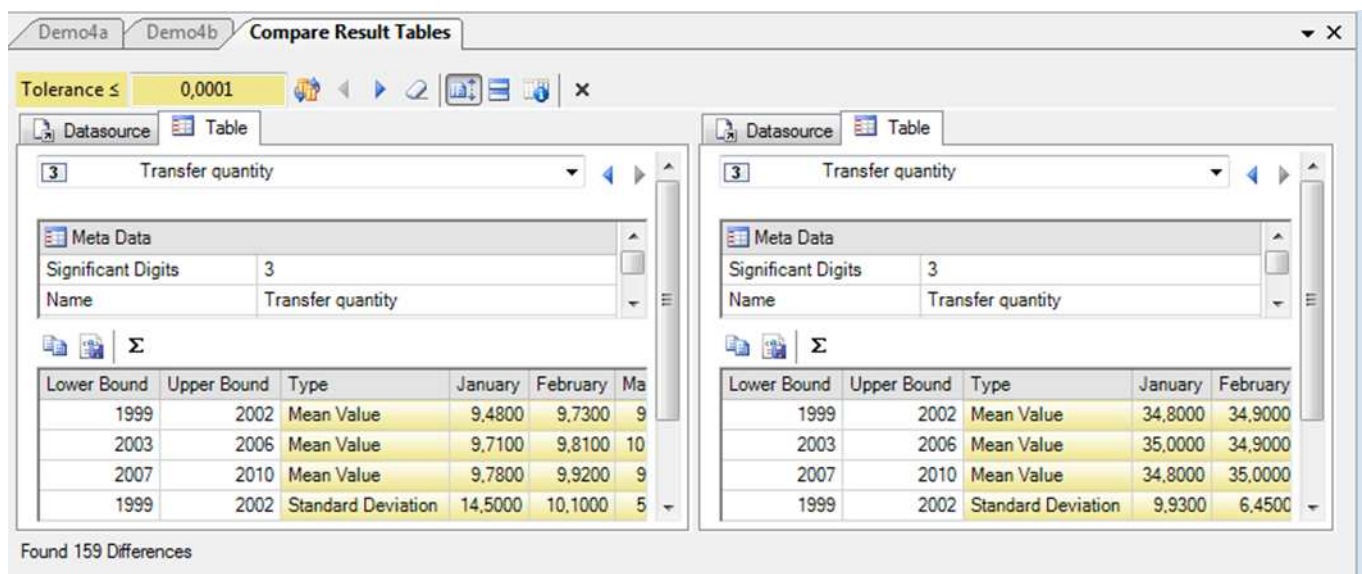
- The table comparison function basically assumes an identical structure for both tables. Where applicable you are informed about differing structures (e.g. variant number of columns). If needed you can hide columns for the comparison: **Display column properties** , select the column you want hidden, **Hide column** . Now start the **Comparison**

- Navigate specifically to the individual differences in the tables . Usually it makes sense to use the synchronous scrolling function to align the positions in both table views.

Tracker

The **Tracker** serves to analyse the model within a time step during simulation. With it, effects of balancing/ executing of ranked model objects on system states can be reproduced.
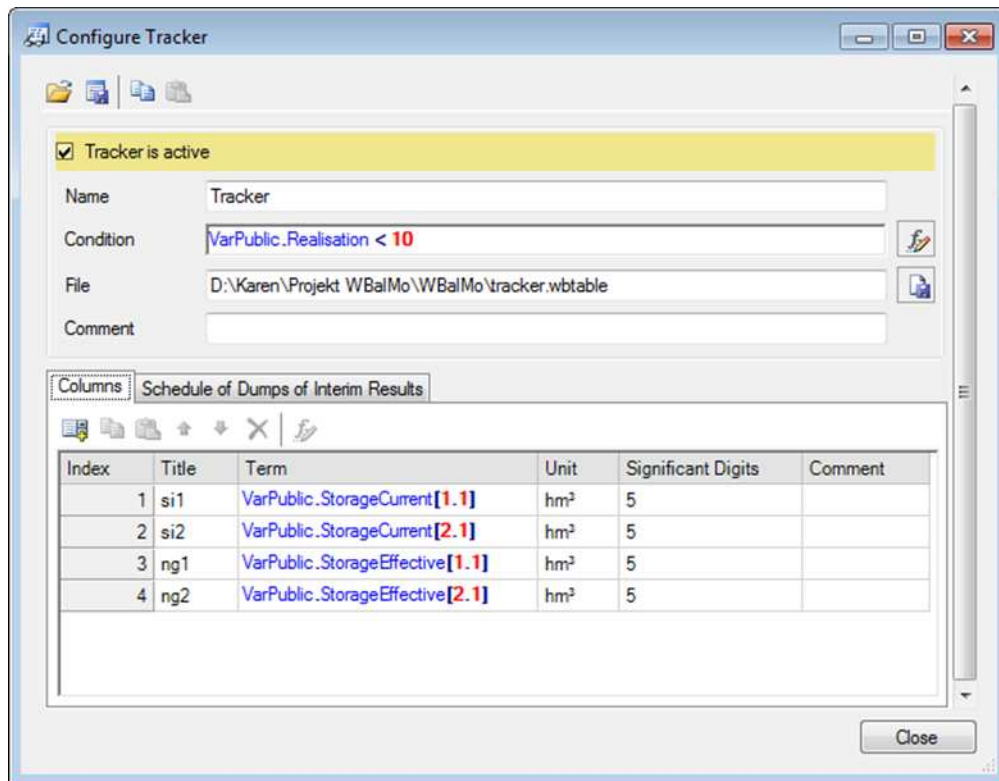
Definition:

- Follow the menu path **Data | Configure tracker**.

- In line with **Registration Type 4**, the following properties are defined:

  o Activation

  o Name

  o no limitation

  o File

  o Comment

  o System states to be analyzed as a column in the results file (title, algebraic term, measure unit)

- The model objects influencing the system states are defined in "Time of output of interim results"

  o Activate tracker output <u>after </u>the model objects of your choice in the ranking list view

  o If required you can also ask for output of the values in the beginning of a time step. These values are usually identical with those in the input dialogs (e.g. withdrawal target of a user).

The structure of the tracker's results file corresponds to that of a **Registration Type 4**. However, here the ranking number of the last balanced/ executed model element is

additionally indicated before output of the tracker line. This ranking number implies the model element causing the effect.

System Sketch

All objects in the management model that are (geo) graphically depictable can be represented in the system sketch. Because it is possible to represent objects in their correct positions, the system sketch enables not only the construction but also the modification of a model. The system sketch is not required for the simulation process. Map the following model elements in the system sketch:

- the network of **Flowing Waters** with balance **Profiles** and **Reservoirs** to be considered

- the boundaries of **Sub areas** to establish natural discharges/ yields

- if needed, e.g. series of climate data (precipitation, evaporation,...) as **Universal time series**

- water Users with their points of withdrawal and return flows at the defined balance profiles

In the created **Sketch**, the drawing objects can be given **Labels**. Information on the drawing objects are displayed to you in tool tips when you hover over them after clicking on the sketch.

In the menu, the sketch item leads you to others:

- **Sketch | Sketch settings:** rendering details for the sketch are defined on the tabs **Layers, Labeling, Current object, Invisible objects** and **Panel options** (the **Panel options** tab is identical to the **Sketch** tab in **Model | Model properties),** and **Overview.**

- The **Snapshot** button copies the currently rendered sketch to the clipboard. Subsequently it can be pasted into a Word document**.**

- **Clear all labels** removes all labels from the sketch**.**

- **Zoom** offers various zoom functions.

Layers

The model object groups are each organized in Layers that are arranged on top of each other in the system sketch. The individual layers can be moved into the foreground or background or be set as visible or invisible.

Open the Layers tab in the menu **Sketch | Sketch settings**. By activating or deactivating the individual object group layers (set/ remove checkmarks), you can make them visible or invisible. Using the **arrow buttons**, you can move active objects to the front or back by one

layer each, where the first object in the list is the uppermost one. If you want to work on an object, you should move the corresponding layer into the foreground.

⬆ ⬇
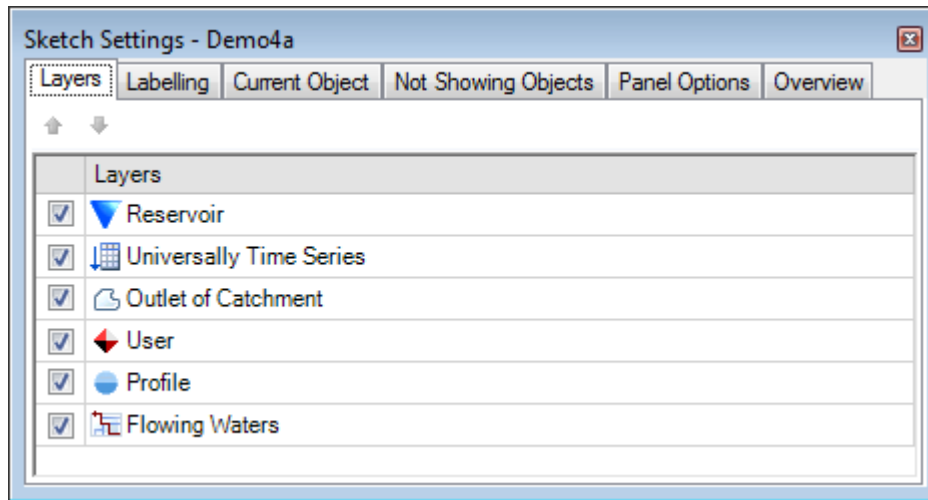
Creating a New Object

Create new object with its proper geometry:

- Activate the specific tool **Flowing Waters, Profile, Sub area discharge, Universal time series, User** or **Reservoir** with the corresponding button in the main menu toolbar and select the option **New** from the dropdown list**.**

If the new object is a point object, such as a balance profile, reservoir or user, indicate its position in the sketch with a left mouse click.

According to the predefined drawing mode, rivers are rendered as lines while sub area discharges and universal time series are rendered as polygons.

Create geometry for an existing data object:

It is possible to create a data object featuring a spatial reference without its proper geometry in the menu **Edit | New** (see also **Creating and deleting data**. Create its according geometry later as follows:

- Activate the object in the navigator and create the according drawing element on the **Sketch** tab (left mouse click, or with rivers: keep left mouse button pressed and draw).

- You can look up data objects with a spatial reference but without geometrical shape in the list of **Invisible objects**. By following the menu **Create new**, you also arrive at the **Sketch** tab (menu path **Sketch | Sketch settings | Invisible objects**).
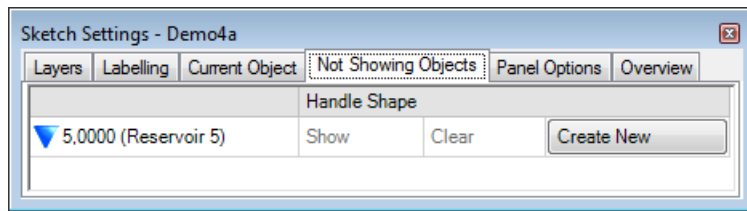
Selection

Preface:

In this context, **selection** stands for the selection of graphic elements in the system sketch for subsequent working steps. It is not to be confused with activation of an object, e.g. by clicking on it in the navigator.

 By using the **Select button**, you can make individual or multiple selections of graphic elements and proceed to work with them.

Select **individual elements** by clicking on them in the sketch.

Select **multiple elements**:

- Select several elements by clicking on the mouse while keeping the control key pressed.

- Drag a rectangle while keeping the mouse button pressed. All objects inside this rectangle will be selected.

Select **multiple areas**:

- You can drag several rectangles while keeping the control key pressed. All objects inside these rectangles will be selected.

Objects activated in the navigator will be highlighted on the sketch tab.

There are various ways to go about working with selected objects:

- On your **Data** or **Sketch** tab: e.g. object information and position in the sketch.

- Via **Sketch | Sketch settings** you can specify on the **Current object** tab whether you want the object hidden or visible in the sketch. You can delete it, zoom to it, or remove its labeling.
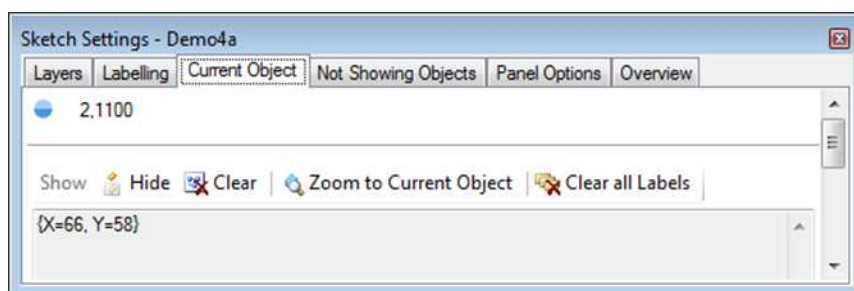
- Using the context menu (right mouseclick in the selection field) you can set, remove, or switch the marking status for the selected objects.

| 2 objects |
| Copy |
| Mark Object |
| Select None |
| Change Marker |
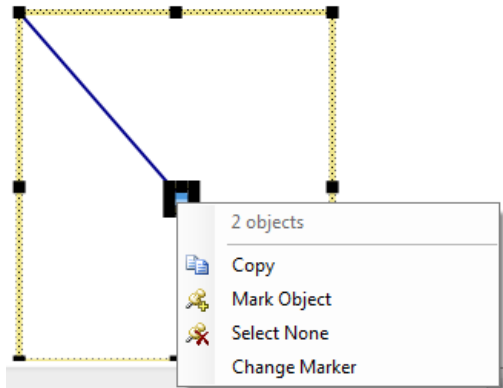
Zoom

To make work with the system sketch easier, you can opt for different views:

Zoom to Full Extent: the displayed section emcompasses all existent drawing elements, including the hidden ones.

Zoom to Current Object: zooms to the extent of the object marked active in the data model (Navigator).

Zoom to Selected: zooms to objects highlighted in the navigator.

Zoom in: magnifies a sketch detail.

Zoom out: miniaturizes a sketch detail.

Zoom to Rect: zooms to a detail indicated by you (drag a rectangle in the sketch while pressing the left mouse button).

Note: Images and labels can be scaled using the **Zoom** dialog on the **Panel option** tab in the **Sketch | Sketch settings** menu**.**

Labeling

In the **WBalMo** menu bar you will find two buttons to edit the labeling:

Clear all labels eliminate all existing labels from the sketch.

Move label: to manually move the label of an object selected in the sketch, the object's layer must be on the top – if this is not the case, move the layer to the top of the object list first (**Sketch | Sketch settings, Layers** tab).

To define the properties for a system sketch's labeling, follow the menu path **Sketch | Sketch settings** to the **Labeling** tab. Here, you can set checkmarks for those objects you want labeled, and whether you want them labeled by **Key, Name** or **Classifications** (or a combination thereof). For the User object group under **Extra** you can additionally activate the option Connect users with profiles, which graphically renders the flow direction of

withdrawals and discharges by the users. Only visible objects can be labeled – the hidden objects are listed on the tab **Invisible objects.**

- ▪ The button **Clear all labels** removes all existing labels from the sketch.

- Activating **Labeling of all data in given layer** causes all drawing elements in a layer to be labeled by the properties marked with checkmarks.

- **Requirements for labeling tool**: if this checkbox is activated, you can selectively label individual drawing elements. For this, set checkmarks at the features of your choice for the specific object group. Then activate the corresponding object group tool in the main menu and select the **Label** option from the dropdown list. Now click on the drawing object in the sketch that you wish labeled with the cursor arrow.

Note: Labels are not deleted when you hide the corresponding layers or individual objects. They are merely made invisible.
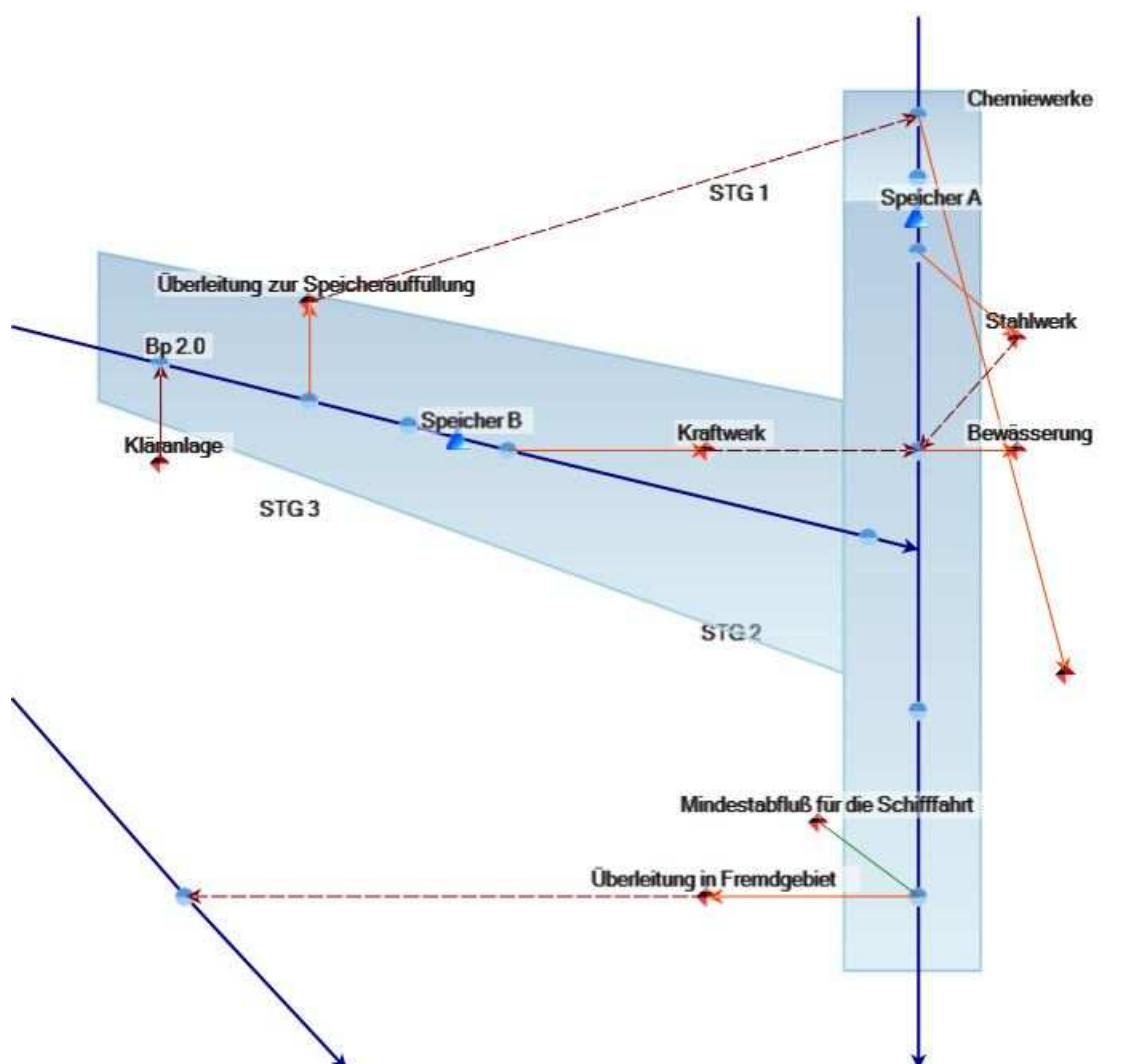
Using the menu path **Model | Model settings | Sketch**, you can determine under **Zoom** whether you want the display of the point symbols and labels to change based on zoom level.

Editing the Geometry

Click the button for the appropriate data group (river, balance profile, etc.) and activate the task **Edit geometry**.

Note: Please remember that the layer, on which the geometry you want to edit belongs to, must be in the foreground of the system sketch. To achieve this, bring the specific layer to the top of the list by using the arrow button on the tab **Layers** tab in the menu **Sketch | Sketch settings.**

- **Move points:** move the geometries of active point objects by clicking on the object in the system sketch and moving it to the desired position with the mouse.

- Change **lines and shapes** by clicking on the object in the system sketch. Then you can drag it at one of its marked node points and move it. Consecutive left and right mouseclicks on a node point open the options **Add point, Delete point, Hide** and **Delete**, which you can use to further edit the objects.
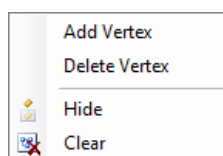
- **Delete geometries:** an object's geometry is deleted. Factual data and references to other data are not affected by this. If needed, you can re-create the geometry.

Invisible Objects

Objects lacking a geometry or the geometry of which is hidden can be found in the **Sketch | Sketch settings** menu on the tab of **Invisible objects.**

Hide an object's geometry:

- To hide an individual object in the sketch, navigate to the tab Current object in the **Sketch | Sketch settings** menu and click the **Hide button**.

Display an object's geometry:

- To redisplay a hidden object in the sketch, navigate to the tab **Invisible objects** in the **Sketch | Sketch settings** menu and click the **Display** button.

Create geometry of an existing data object:

- Follow the menu path **Sketch | Sketch settings** to the **Invisible objects** tab and click the **Create new geometry** button. Now you can create the geometries of point objects by mouse click and that of line and shape geometries by drawing in the sketch.
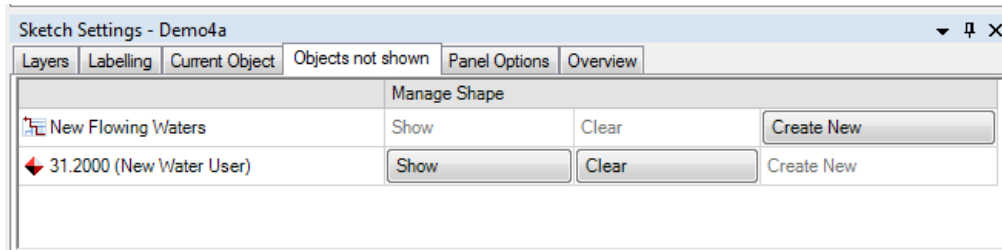
Configuring the Drawing Area

In the sub menu **Sketch settings**, you can configure your drawing area. To get there, open **Sketch settings|** tab **Panel options.**
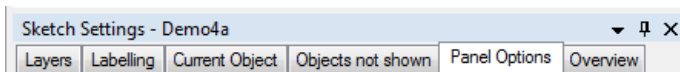
On the **Panel options** tab, you can decide whether you prefer the **drawing mode** "Straight line" or "Freehand" for lines or polygons. In the **Raster settings** group, you can lay a raster on your sketch und select the option to have your drawing elements aligned to it. You can also define the distances in x and y direction and the point of origin. Under **Zoom**, you can determine whether you want the sizes of the symbols and labels in your sketch to be upsized or downsized with the zoom, or whether you want them to keep their sizes. If the option **Scale images** is activated, labels and symbols are accordingly up- or downscaled with the zoom.

In the last group, you can specify your preferences for displaying information in the form of **tooltips** in the sketch. You can also set to be shown the present **coordinates** of the mouse position in the status bar.

Position: X=87, Y=90; Geographic Coordinates: X=61.90978, Y=58.88416
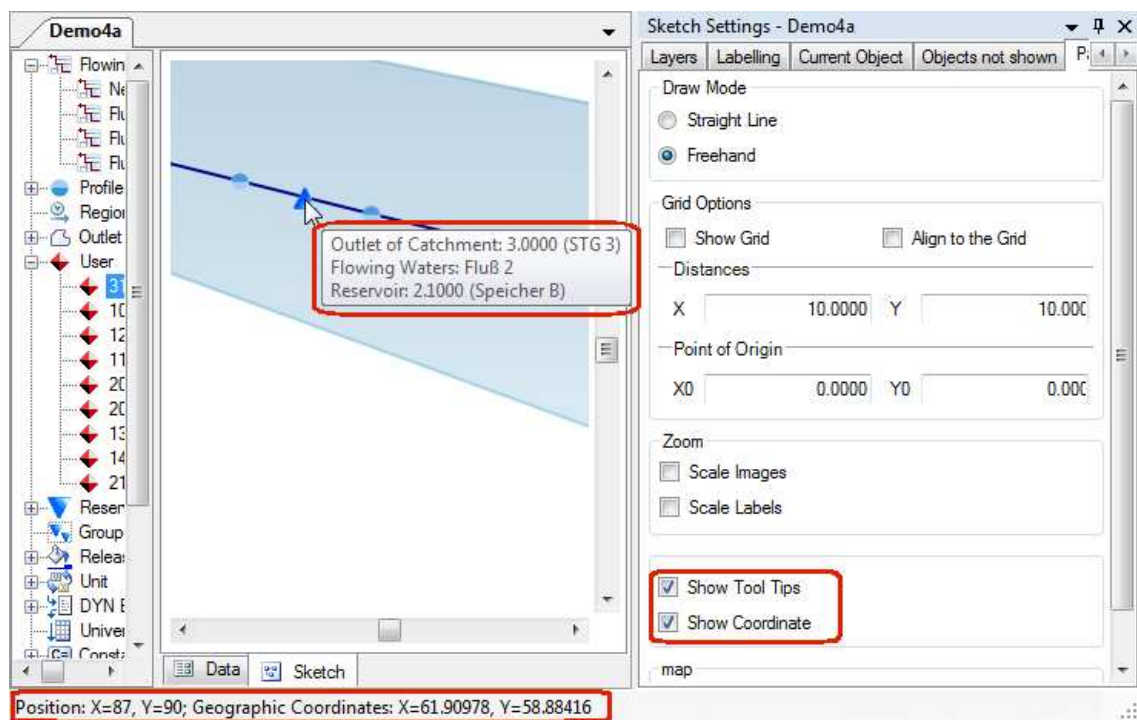
Example

This example is meant to assist you in the application of **WBalMo**. We will examine a water resources management system consisting of two main river branches and a tributary, where the two main rivers are connected to each other by an artificial diversion. In total, eight users and Reservoir A belong to the system. The system is assumed to be able to covering some usage demands with limited security. Therefore, the possibilities for to improve this unsatisfactory situation with the help of a new Reservoir B. For this investment problem it makes sense to study the system behavior throughout three consecutive periods:

Period 1:	Previous system with Reservoir A
Period 2:	System with new Reservoir B in the transient start-up phase
Period 3:	System Reservoir B in the stationary state.

The period length is assumed to be four years, where the first year of a realization is set to 1999. By applying an appropriate registration the effect of the new reservoir can be established.

Following graphical mapping of the system according to the figure, the system with its internal natural and utilization processes is described using data groups.
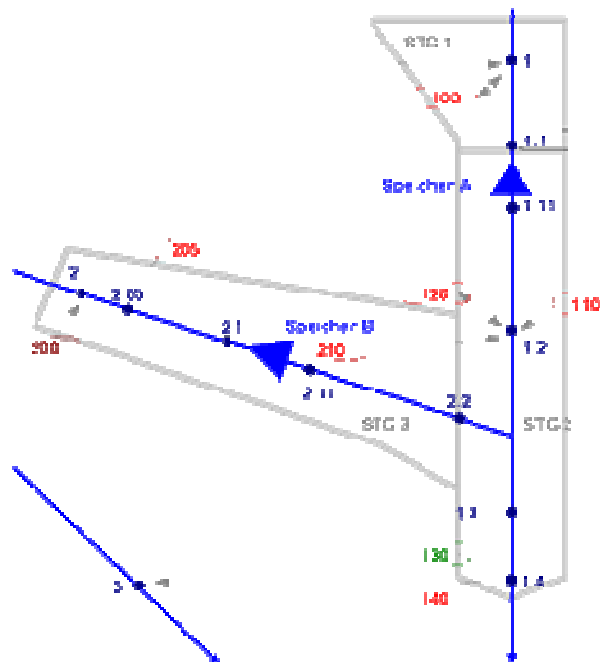
Model structure

Twelve balance profiles were defined to arrange the water utilizations in their correct positions, with the balance profiles 1.11 and 2.11 representing the reservoir release profiles.

1   1.1   S 1.1   1.11   1.2   1.3   1.4   → Ø

2   2.05   2.1   S 2.1   2.11   2.2   → 1.3

3   → Ø

Sub area discharges

To record the natural water yield, three sub area discharges are defined according to the positions of three long-term observation gauges:

Gauge Adorf	in balance profile 1.1 (as inflow gauge for reservoir 1.1)
Gauge Bstadt	in balance profile 1.4 (contains discharges of other two gauges)
Gauge Cdorf	in balance profile 2.2 (gauge at tributary river mouth).

The second main river's discharge in balance profile 3 shall not concern us. The figure shows the positions of the sub area discharges.

Long series of monthly means discharges with corresponding time patterns and adjusted for utilizations are needed for the gauges. In the example, adjustments affect losses by users upstream in the sub area, and storage effects by Reservoir A. These series can either enter directly into the **WBalMo** calculation or serve as the basis for a stochastic discharge simulation model. The latter, more preferable path leads to series of any desired length, a prerequisite for high accuracy in **WBalMo**'s results.

This said, the following applies for the sub area discharges:

Name	Key	File
Sub area discharge 1	1	adorf.dat
Sub area discharge 2	2	bstadt.dat
Sub area discharge 3	3	cdorf.dat

The sub area discharge series provided for this example encompass 1200 years at 12 months each. They thus allow a **WBalMo** calculation over maximum 100 realizations at 3 periods with 4 years each.

Because as a rule several balance profiles are sited in one sub area, its discharge is to be divided up between the intermediate areas between successive balance profiles with their relative shares. These shares are usually determined by the ratio intermediate area/ sub area, and more accurate calculations additionally take into account the mean precipitation heights inside the sub area.

The following values were assumed:

Balance profile	1	1.1	1.11	1.2	1.3	1.4	2	2.05	2.1	2.11	2.2	3
Sub area discharge 1	0.9	0.1		-0.3	-0.45	-0.25						
Sub area discharge 2				0.3	0.45	0.25						
Sub area discharge 3				-0.3	-0.45	-0.25	0.2	0.3	0.4		0.1	

Hence it is presumed that e.g. 90% of the discharge from sub area 1 flow as far as Balance profile 1, and the rest of 10% are yielded by the intermediate area between Balance profiles 1 and 1.1. Sub area discharge 2 represents a specialty in that the used discharge in Balance profile 1.4 contains the sub area discharges 1 and 3. If the areal shares between balance profiles 1.1, 1.2, 1.3 and 1.4, amount to 30, 45 and 25%, respectively, of sub area 2, then the discharge between Balance profiles 1.1 and 1.2 amount to 0.3•(Teilgebietsdargebot2-Teilgebietsdargebot1-Teilgebietsdargebot3), between Balance profiles 1.2 and 1.3 amounts to 0.45•(Teilgebietsdargebot-Teilgebietsdargebot1-Teilgebietsdargebot3) etc. (Negative shares can be avoided by starting from the difference series of discharges between the three gauges.) The two Reservoir relase profiles 1.11 und 2.11 are assigned no discharge.

Users

The following overview contains the information needed on the eight users:

Name	Key	Type	Withdrawal profile	Return flow profile	Measure unit	W	R	Rank
Chemical plant	100	R	1	1	hm³/Mon	1.5	1.2	0.6
Steel plant	110	R	1.1	1.1	Tm³/d	150	135	2
Irrigation	120	R	1.2	1.2	hm³/Mon	*)	0	5
Minimum discharge for navigation	130	Qmin	1.4		m³/s	35		1
Diversion to external region	140	R	1.4	3	m³/s	10	10	4
Waste water treatment plant	200	CR		2	hm³/Mon		1.1	0.5
Diversion for reservoir replenishment	205	R	2.05	1	m³/s	0 **)	0 **)	7
Power plant	210	R	2.11	1.2	m³/s	10	9	3

*) Yearly variation:

May	2.2
June	5.0
July	6.0
August	6.0
September	2.2
other	0

**) The actual quantities of withdrawal and return are calculated in a DYN element.

All utilization data are valid for 3 periods.

Reservoir

The two reservoirs are defined with the following data.

Name	Key	SC	Initial filling	Effective storage capacity		Rank of AEND element
		hm³		Periode 1	Periode 2, 3	
Speicher A	1.1	250	0.5	*)	*)	8
Speicher B	2.1	350	0	0	350	6

*) Yearly variation:

January	200
February	180
March	180
April	210
May	240
June	240
July	240
August	240
September	240
October	240
November	230
December	220

Reservoir A exists in all periods and its effective storage capacity varies in different months. This makes it possible to easily record flood protection capacities with seasonally varying volumes. The reservoir is assumed to be half filled at the start of calculation (FSK= 0.5).

Reservoir B is only taken into operation in the beginning of the 2nd period, so that its effective storage capacity has to be set to zero in period 1. Afterwards, the effective storage capacity is assumed to be constant.

Release elements

Management of the two reservoirs is governed by 3 release elements with the following data:

Name	Key	Storage	G	BETA	Rank
Release for Qmin navigation	1.11	1.1	10	0	0.99
Release for irrigation	1.12	1.1	160	0	4.99
Release for diversion and power plant	2.1	2.1	0	0	2.99

The two first mentioned elements set the storage targets of Reservoir A to 10 and 200 hm³. In connection with the according ranking numbers, this means that water volumes

exceeding the storage targets are made available to the users further down the ranking list. However, if the actual current storage volume is below these storage targets, the users will not be sustained from the reservoir but on the contrary, it will be attempted to use part of the reservoir inflow to replenish the reservoir.

The 3rd release element arranges that all water available in Reservoir B is provided to the lower-rank users.

Numeric parameters

The capacity of water transfer to replenish Reservoir A by discharge from the tributary is added as a numeric parameter to be used in the DYN element:

Index	Value	Description
2	5	max. diversion capacity starting from balance profile 2.05 in m³/s

DYN elements

Diversion to Reservoir A is controlled by the only DYN element:

Name	Calculation of diversion for reservoir replenishment
Rank	6.99

DYN text (FORTRAN)

```
if (Discharge(2.05) > 5. * 2.628 .and. StorageCurrent(1.1) < 200.) then
val = ConstNumber(1., Min(Discharge(2.05) - 5. * 2.628, ConstNumber(2.) * 2.628))
else
val = ConstNumber(1., 0.)
end if
val = Withdrawal(205., ConstNumber(1.))
val = Returnflow(205., ConstNumber(1.))
```

The algorithm determines that diversions are only permitted either if discharges exceeding 5 m³/s occur at balance profile 2.05, or if reservoir volume drops below hm³. The quantity is limited by the share of discharge exceeding 5 m³/s as well as by the diversion capacity of 5 m³/s laid down in ConstNumber (2). It is important that the DAYN element's ranking number is smaller than that of user 205.

Ranking list

As we know, utilization processes in **WBalMo** are simulated by entering all quantities with ranking numbers (such as users, release elements, and DYN elements in a ranking list in ascending order of their ranking numbers, and by then successively processing this list starting with the smallest ranking number.

In the present case this results in the following list:

Type	Key	Name	Rank

Type	Key	Name	Rank
N	200	Waste water treatment plant	0.5
N	100	Chemical plant	0.6
AB	1.11	Release for Qmin navigation	0.99
N	130	Qmin navigation	1
N	110	Steel plant	2
AB	2.11	Release for diversion to external region	2.99
N	210	Power plant	3
N	140	Diversion to external region	4
AB	1.12	Release for irrigation	4.99
N	120	Irrigation	5
AEND	(2.1)	Reservoir B	6
DYN		Release for diversion for reservoir replenishment	6.99
N	205	Diversion for reservoir replenishment	7
AEND	(1.1)	Reservoir A	8

The list indicates that

- independent of any conditions, the WWTP releases its discharge to into Balance profile 2, and the chemical plant may withdraw as long as balance profile 1 can supply,

- Reservoir A may draw down to the target level of 10 hm³, in order to preferentially support navigation (N 130) and the steel plant (N 110),

- the new Reservoir B preferentially supplies the power plant (N210) and the diversion to the external region (N140),

- Reservoir A only prioritizes irrigation (N120) if its charge exceeds 160 hm³ and

- replenishment of Reservoir A from the tributary is only carried out under the conditions defined by the DYN element,

- in times of plenty discharge, Reservoir B is given priority to Reservoir A in terms of replenishment from their respective inflows (Rang(AEND 2.1) < Rang(AEND 1.1), in order to make better use of the larger storage space in Reservoir B.

Registrations

To assess the effectivity of the preset management conception, the following registrations were defined:

Type	Term	Description	Result
1	VarPublic.Discharge[1.4]	Discharge at balance profile 1.4	Certainty of minimum discharge for navigation
1	VarPublic.WithdrawalBalanced[210]	Current withdrawal by power plant	Certainty of supply of power plant
1	100*(VarPublic.WithdrawalBalanced[140]/(VarPublic.Withdrawal[140]))	Relative coverage of diversion demand	Certainty of covering diversion demands into external region
2	VarPublic.Discharge[1.4]<VarPublic.Withdrawal[130]	Shortfall of minimum discharge for navigation	Frequency of shortfall during several months
3	VarPublic.StorageCurrent[1.1]	Storage level Reservoir A	Mean reservoir storage levels for selected years
3	VarPublic.StorageCurrent[2.1]	Storage level Reservoir B	Mean reservoir storage levels for selected years
3	VarPublic.WithdrawalBalanced[140.0]	Quantities of diversion into external region	Mean diversion quantities in individual years

Results

The system to be calculated including its discharge and utilization processes are completely described by the data explained above. Following a simulation over 100 realizations the results are stored in a file. A brief discussion of the results will demonstrate how to interpret them.

The following essential characteristics can be inferred from the three registrations type 1:

Registration quantity	Term	Value	Certainty [%]	Period 1	Period 2	Period 3
Discharge in balance profile1.4	VarPublic.Discharge[1.4]	35 m³/s	S (October)	76.0	92.8	93.5
			SD	91.1	96.4	97.0
Current withdrawal power plant	VarPublic.WithdrawalBalanced[210]	10 m³/s	S (October)	70.5	89.3	92.3
			SD	89.4	96.5	97.3

Relative coverage of diversion demand	100*(VarPublic. WithdrawalBala nced[140]/(VarP ublic.Withdrawa l[140]))	100 %	S (October)	67.5	90.0	93.3
			SD	87.3	96.0	96.5

For period 1, before Reservoir B was taken into operation, it shows that certainties are very low not only in October (usually the worst month in the example) but also for the duration of any values of interest. Thus the certainty of 76% for a minimum discharge for navigation of 35 m³/s in October indicates that this discharge can only be kept in 3 of 4 years in October. The certainty SD of 91.1 % expresses that a shortfall of the minimum discharge can be expected approximately every 1 months. The certainties for the two other essential usages are even smaller, and for the power plant completely inacceptible. The system existing in period 1 is overstretched.

Starting with the beginning of the second period, Reservoir B takes on effect, as certainties rise considerably and reach acceptable levels. Comparing certainties in the periods 2 and 3 to each other, they further rise slightly. This mirrors the fact that the filling phase of new Reservoir B is completed in period 3.

Registration type 2 examines the frequency with which phases of severall months start in the individual months where the minimum discharge target is not reached in Balance profile 1.4. By summing up the frequencies, e.g. in September, it becomes obvious that in period 1, a phase of several months starts with a certainty of 6% and this certainty falls to around 2% in the two other periods. In the remaining months, a similar tendency is recognizable. These results underline the indications of Registration type 1 in a different way.

The next two tables of Registration type 3 mirror the mean behavior of the storage levels for both Reservoirs A and B over the 12 years of the balance period. Considering only the means yearly storage levels, a gradual rise is seen in Reservoir A starting from period 2 associated with the filling of Reservoir B. Period 3 is characterized by consistant mean storage levels. Starting in period 2 the new Reservoir B displays a corresponding behavior. The start of the stationary storage phase in Reservoir B can also be read from the stabilization of the mean minimum storage levels (MNQmon) in period 3.

The last table of Registration type 3 indicates the mean diversion quantities into the external region. Here the commissioning of Reservoir B is evidenced by the diversions increasing by an average of 8.9 m³/s in period 1 to approximately 9.7 m³/s in the other two periods.

Changing the reservoir's drawdown targets or the ranking numbers of users, release elements, or DYN elements result in changes in certainties for the various users. If usage demands are kept constant and a fixed system of individual user's importances to each other is in place, roughly optimal management strategies can thus be developed using calculations of variants. In case some certainties remain below an expected level, either some usage demands must be withdrawn, or further water management measures (such as setting up more reservoirs and diversions) must be considered.
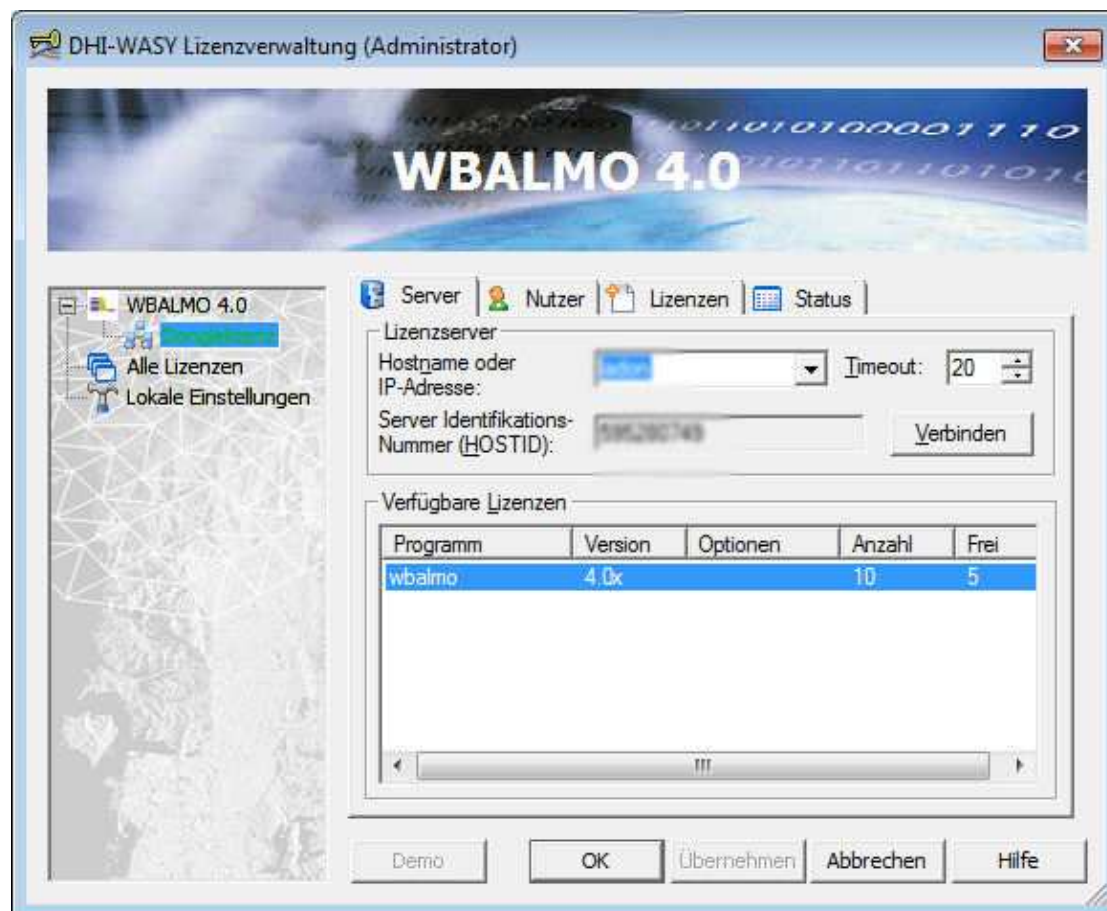
Extras

Licensing and Demo Version

Licensing with NetLM

Connecting to License Server

If **WBalMo** is licensed by a floating license in the network, you specify the license server managing the according licenses in this menu.

When the connection is active, all available licenses are listed.

The following steps are necessary to build the connection to the license server:

- Enter the name (**Hostname**) of the license manager. If you want to connect with your local computer, enter "localhost". In case no local license manager is installed, a dialog window appears in which you can start the local installation.

- Click **Connect**. If the connection was successfully established, the license server's unique identifier (**HOSTID**) appears in the field "Server identification
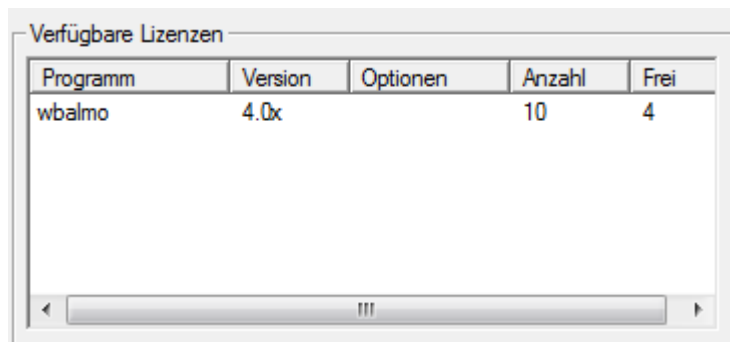
number (HOSTID)". Otherwise you receive an error message informing you of the reasons for the failed connection.

- Select one of the available licenses to work with the indicated program. The OK button only becomes active if the highlighted license coincides with the initialized application (in this case **WBalMo** version 4.0).

Roles of the Applications

The tool for license administration was developed to administer the licenses for all DHI-WASY products. By default only the relevant information for the currently running program are shown. Activate the option "**Show all**" to see which licenses for other DHI-WASY programs are available on the license server. **Note** that you can also install licenses for DHI-WASY applications other than the initialized application.

List of Available Licenses

Verfügbare Lizenzen				
Programm	Version	Optionen	Anzahl	Frei
wbalmo	4.0x		10	4

The list shows all the licenses currently installed on the license server. You can customize the display by controlled application (see section above). The table contains the following columns:

- **Program:** Name of licensed application. Renaming the application does not affect this value.

- **Version:** Version extent of the license. The "x" is a placeholder for a random number. Please note that all licenses are downward compatible. Hence e.g. a **WBalMo** 4.0x license encompasses a valid license for **WBalMo** 3.0 (! Only network licenses are downward compatible).

- **Options:** The string defines the application's individual extension (e.g. licensed modules in **WBalMo**).

- **Number:** Number of simultaneously usable licenses.

- **Free:** Number of currently available licenses. A dash in this column indicates an invalid license. For further information refer to the license section ("License indications". Very likely, either the license or the dongle-ID has expiredt.

License Entries

In this menu the license parameters are indicated. License modifications and the initial license entry are also made in this menu.
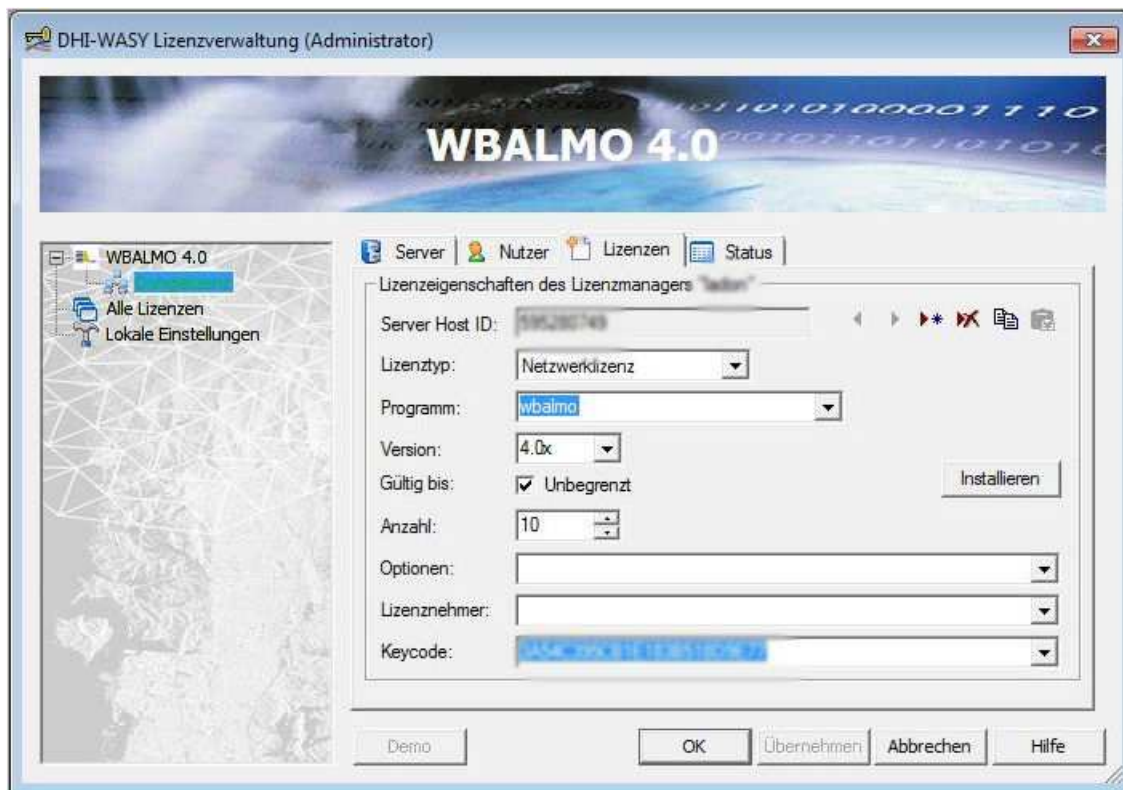
Entering License Information

Each license contains 9 different entries which are to be indicated using the license transferred by **DHI-WASY**.

The following fields must be filled in:

- **Server Host ID**: - not editable – each license is linked to a particular license server identified by a unique identifier, the host ID. This ID is coded on the hardware dongle. For this reason it is important to use the proper dongle when installing a new license.

- **License type:** Indicates the nature of the license, whether network or single user license.

- **Program**: enter the name of the application you want to license. No distinction is made between upper-case and lower-case letters. Do not add the file extension (.exe).

- **Version**: Selection of the licensed program versions. The "x" is a placeholder for a user-defined number. All program versions up to this number ("x" is internally replaced by "9") may use this license.

- **Valid until**: For temporarily limited licenses: date of license expiry, otherwise unlimited. Valid formats are the following:

  (a) dd-mmm-yyyy 31-mar-2002

  (b) yyyy/mm/dd 2002/03/31

  (c) dd.mmm.yyyy 31.03.2002

  dd - day, mmm - month, yyyy - year.

- **Number:** Number of licenses. This field indicates the maximum number of licenses that can be used simultaneously.

- **Options:** The options string has a direct effect on the licensed appliucation. Certain optionally available modules are unlocked or deactivated in the application by this string.

- **License holder:** Indicates the license holder**.**

- **Keycode:** The keycode (key) contains a checksum of all license values entered to date. Therefore the keycode must coincide with the other license parts. Even minimal modifications of the license values affect this entry. The following rules must be observed when making an entry:

  (a) no distinction is made between upper-case and lower-case letters,

  (b) the letter O is interpreted as a zero,

  (c) all characters except for A - Z and 0 - 9 are ignored.

! No distinction is made between upper-case and lower-case letters in any of the fields except for the option field. The option field is interpreted by the licensed application, and **WBalMo** also does not differentiate between upper-case and lower-case letters.

With the toolbar you can navigate to the previous / next license, empty all input fields for a new license, delete an existing license, and to avoid input errors, all license entries can be pasted from the Windows® clipboard, provided the license has been delivered by email. The email must contain the following indications:

- **ServerHostid:** <license server host ID>
- **ClientHostid:** <empty> or <client host ID>
- **Program name:** <Name of program>
- **Program version:** <indication of program version>
- **Expiry date:** < indication of expiry date>
- **Number of licenses:** <number of licenses bought >
- **Options:** <License options>
- **Keycode:** <24 characters keycode>

For example:

ServerHostid:	7270167e
ClientHostid:	
Program name:	**WBalMo**
Program version:	4.0
Expiry date:	25-mar-2014
Number of licenses:	2
Options:	201-TEST
Keycode:	074491E4275988EAAE37E585

Status of License Server

This menu provides all information on the license server.
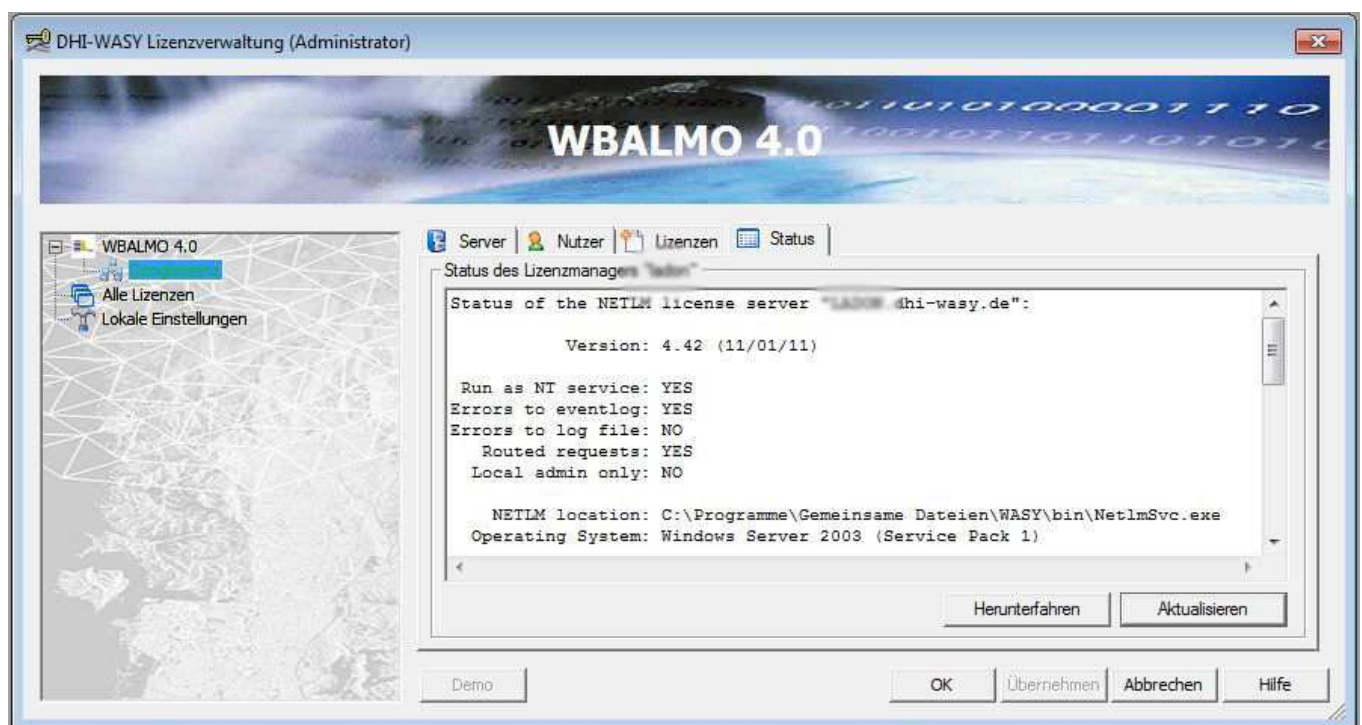
The status page gives more detailed information on the license server's internal parameters. Every license server available in the network can be monitored by the built-in protocol.

In practice, these informations can be useful for troubleshooting. If you have activated the license server's protocol options, you can send the status messages directly to the **DHI-WASY GmbH** support department.

License Dialog: Active Users

All users logged into the license server are listed in this menu. Additionally to the name (user), the program, licensed program version (version), computer name (Host), as well as the display status (display) and time of login to the license server are displayed (login).

This page contains information on all the license server's active client connections. The display can be used to find out which user is using a specific license on which computer: This page show the following columns:

- **User:** this column contains the user name of the user who has started the licensed application.

- **Program**: this column ontains the application's initial program name. Renaming the application has no influence on this column's contents.

- **Version**: in the version column, the program version number of the licensed application is indicated. Since the license bought can also contain many versions and smaller updates, the displayed version can differ from the actual **WBalMo** version. The version number is shown with an accuracy of up to 3 decimal places.

- **Host:** the host column indicates the name of the computer the application was started on.

- **Display:** the value in this column should always be "local" in **WBalMo**. This column is only relevant for X11 applications (e.g. Feflow). With these X11 applications, the application's display can be redirected to a different computer.

- **Login:** indicates the time of login to the license server.

Disconnecting a Client from a License Server

Each client who has received a license from the license server maintains a permanent TCP/IP connection to the license server. An "end of file (EOF)" signal received by the license server on this connection indicates that the client has closed the application. The license server then unblocks the formerly used license for other clients.

If the connection to the client is unexpectedely interrupted, e.g. by a system crash, the license server does not know that the license is no longer used. In this case you must unblock the license manually. Follow the following procedure:

- mark the connection in question
- click the Finish button
- click the Refresh button

to ensure that the license has been unblocked for other clients.

Demo Version

If no valid license is available for **WBalMo**, the program will start in the limited demo mode.

The following functions are deactivated in the demo mode:

- open/ save project
- import **WBalMo** 3 and earlier
- compare models
- configure extended system variable
- configure tracker
- clip board manager.

In the demo mode you can edit models up to a certain size and initialize simulation calculations.

 The model size may not be exceeded:

- 15 balance profiles
- 3 sub area discarges or universal time series
- 2 reservoirs
- 5 release elements
- 10 users
- 2 DYN elements
- 5 constant (double) or (string) elements
- 10 registrations
- maximum 3 periods
- maximum 5 realizations

Otherwise the following limitations apply:

- o Changes are not saved

- o Model report and simulation calculation are not possible

- o The tools File references, Search and Configure OpenMI parameters are not available.

Glossary

Index of Abbreviations and Symbols

Abgabe-End-Element	Special storage release to return unclaimed water to a reservoir or reservoir association
AE	Actual withdrawal by a user after his balancing; program variable "WithdrawalBalanced"
ANZP	Number of periods; program variable " PeriodCount"
ANZR	Number of realizations; program variable " RealisationCount"
AR	Actual discharge or return flow by a user after his balancing; program variable " ReturnFlowBalanced"
BETA	Coefficient to calculate maximum or minimum storage target depending on SIA; program variable "StorageTargetRelative"
DYN-Element	Dynamic element; individual, model specific routine of a runtime library (.DLL) to interrupt the standard algorithm
E	Withdrawal demand by a user; target value; program variable " Withdrawal"
G	Maximum or minimum storage target [hm³] of a reservoir; program variable " StorageTarget"
GR	Limit value at subdivision of a reservoir in case of combined reservoir management [hm³]; program variable "StorageIntermediateLevel"
IGR	Number of slices into which the reservoir volume is subdivided up to GR at combined management
ING	Number of slices into which the reservoir volume is subdivided from GR to NG at combined management
JAHR	Current year within one period; program variable " YearPeriod"
LP	Length of a period in years; program variable " PeriodLength"
MON	Current month; program variable "Month"
NG	Effective storage capacity of a reservoir [hm³]; active capacity; program variable " StorageEffective"
R	Return flow target for a user; program variable " ReturnFlow"
SI	Reservoir level during or after calculation in a month [hm³]; program variable "StorageCurrent"
SIA	Reservoir level at beginning of a month [hm³];
SK	Storage capacity [hm³]; maximum active capacity; program variable "Capacity"
Z	Ranking number