
A Guide to Aquator

10 HYSIM

Version 4.2

Oxford Scientific Software Ltd.



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Contents

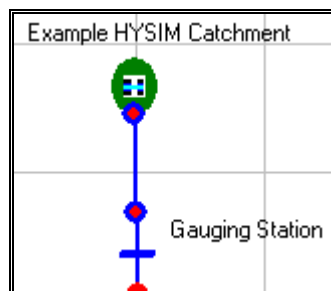
HYSIM Catchment	1
How HYSIM Catchment Works	1
HYSIM Catchment.....	2
Connectors	4
Properties	5
Parameters.....	6
States	6
Variables	6
Sequences	7
Constraints	9
Interfaces.....	9
Resource State.....	9
Status level.....	9
Special Methods.....	9
AddSWDischarge	9
AbstractGW	10
Properties	10
Arrow.Head, Arrow.Angle and Arrow.Size	10
Component.Display name	11
Component.Draw order	11
Draw.[Line attributes]	11
Draw.[Fill attributes]	11
Draw.Font.....	12
Draw.Shape.....	12
Draw.Text	12
Info.Identifier, Info.Grid Reference, Info.GIS Reference, Info.Cross Reference, Info.Owner, Info.Location, Info.Manager, Info.Other,.....	12
Options.Show name	12
Schematic.Left, Schematic.Top, Schematic.Width and Schematic.Height...12	
Schematic.Name X, Schematic.Name Y, and Schematic.Name Angle.....12	
Shell.Caption, Shell.Path, and Shell.Arguments	12
Parameters	13
Flow output.Method.....	14
Options.Animate on.....	14
Operation.Demand saving	14
Options.Enabled.....	14
Options.Events on.....	14
Options.Trace on.....	14
Options.Trace flags	15

Prediction.Accuracy.....	15
Recession.Coefficient.....	15
Recession.Factor.....	15
Recession.Time constant.....	16
Scaling.Catchment rainfall.....	16
Scaling.Catchment PET.....	16
Scaling.Catchment outflow.....	16
Scaling.Additional snowmelt.....	16
States.....	16
Variables.....	16
Flow.Model.....	16
Flow.Recorded.....	17
Model input.Rainfall (1 – 3).....	17
Model input.PET (1 – 3).....	17
Model input.SW discharge (1 – 3).....	17
Model input.GW abstraction (1 – 3).....	17
Model input.Snow melt (1 – 3).....	17
Operation.Status level.....	17
Sequences.....	18

HYSIM Catchment

How HYSIM Catchment Works

HYSIM Catchment is an Aquator Component that provides flow input to a river reach Component in a same way as the basic *Aquator Catchment Component*. (see Chapter on ***Aquator Components***).



In the basic Catchment *Component* these flows are provided by either a time series or profile of flows stored on the database. HYSIM Catchment differs in that the HYSIM hydrological Catchment model is used to generate river flows by simulation on a day by day basis from meteorological data.

More information about the HYSIM Catchment model can be found at: <http://www.watres.com/software/sf-hysim.html>

HYSIM Catchment requires the following three items of software to run:

- (a) **Aquator's HYSIM Catchment Component**. This is the object that appears on the Aquator tool bar and can be dropped onto the schematic. It has no HYSIM functionality of its own. Its main function is to provide data to (b) and (c) below which do the *real* calculations. (This Component is supplied and supported with Aquator).
- (b) **HYSIM Catchment Model – Calibration**. This is the full HYSIM Catchment model with facilities for deriving calibration parameters for a Catchment. This is a separate application and is invoked by (a) above to

undertake a Catchment calibration. (*HYSIM.exe* is supplied and supported by Water Resource Associates).

- (c) **HYSIM Catchment Model – Simulation.** This is the part of the HYSIM Catchment model which generates daily flow values and is invoked by (a) above during an Aquator model run to calculate flow. (*HYSIMCalc.dll* is supplied and supported by Water Resource Associates).

If *HYSIM.exe* and *HYSIMCalc.dll* are not installed and registered, this Component will be unavailable to Aquator.

Potential users of this Component should:

- Have already installed a version of *HYSIM.exe* that is compatible with Aquator.
- Have already installed a version of *HYSIMCalc.dll* that is compatible with Aquator.
- Be familiar with HYSIM and its calibration methods before proceeding.

This Chapter describes *Aquator's HYSIM Catchment Component* only. *HYSIM Catchment Model – Calibration* and *HYSIM Catchment Model – Simulation* are supported by Water Resource Associates directly to whom any queries should be directed.

With all of the above items of software in place, a typical sequence of events to make use of this *Component* would be:

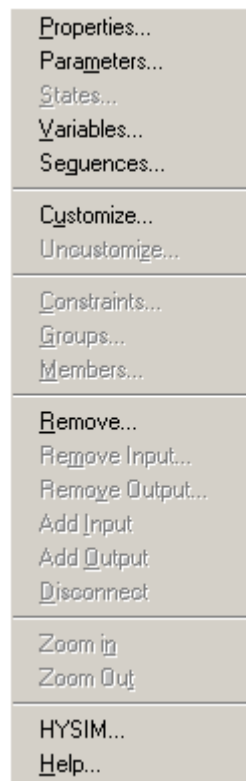
1. Place a *HYSIM Catchment Component* on the schematic and join it to the river network.
2. Calibrate that Catchment and store the calibrated parameters on the Aquator database.
3. Use the calibrated parameters to generate daily flows by simulation in an Aquator model run.

HYSIM Catchment



A HYSIM Catchment adds water on a daily basis to the river network.

The HYSIM Catchment must be calibrated before it can be used to generate flows. Calibration involves an understanding of the hydrology of the Catchment and a knowledge of HYSIM. Calibrate the Catchment by first assigning time series to all relevant sequences. The right click on the HYSIM Catchment on the schematic and select *HYSIM ...* from the last line of the context menu:



HYSIM should now run and all its features be available. Aquator is disabled when running HYSIM in the mode. To return to Aquator it is first necessary to exit HYSIM. Only one HYSIM Catchment at a time can be calibrated. Sequence data assigned in Aquator and stored on the Aquator database are now available in HYSIM. Parameters fitted during a HYSIM calibration should first be saved in HYSIM. This process transfers the parameters to Aquator. Be sure to save your Aquator project before closing so that the these parameters (and any other changes you might have made) are stored on the database.

Having calibrated a Catchment it may then be used to generate flow in an Aquator model run.

An observed (recorded) flow sequence may be attached to this *Component*. This is used in Catchment calibration. As an option it may also be either used as the only source of daily flow (i.e. as a complete substitute for model flow) or used when available and in-filled with model flows at other times. This option is a parameter of the *Component (Flow output.Method)*.

For the VBA programmer there is an opportunity to easily allow other *Components* to interact with a HYSIM Catchment. For example one or more Aquator groundwater *Components* can apply a groundwater abstraction on the HYSIM Catchment. This

will deplete the HYSIM Catchment's internal groundwater store and cause reduced river flows as a consequence in the days ahead. See *Special Methods* below for more information on this.

When a forecast of future catchment flows is required by downstream components, these are obtained by the flowing method:

1. A lower estimate of flow 'n' days ahead is made using catchment's recession curve with today's flow is used as the starting point. The recession constant parameter is then applied*. This is an estimate of the flow that would occur if there were to be no rainfall for the next 'n' days.
2. The 'actual' flow 'n' days ahead is obtained from:
 - Either the time series (or profile) defining the catchment's flow if the parameter *Flow output.Method* is either *Recorded flows only* or *Recorded infilled with Model* and today's recorded flow is missing. This represents the true value of flow and would be expected to be greater or equal to than the recession curve value since any rainfall would increase the flow above the recession value.
 - Or, if the above condition is not the case, today's HYSIM flow. i.e. HYSIM is not asked to make a forecast.
3. Using a prediction accuracy parameter, the value of flow predicted 'n' ahead is in the range estimate 1 above (zero prediction accuracy) to estimate 2 above (100% or perfect prediction accuracy)

* The recession constant parameter can be supplied in one of three ways:

Factor:

$$Q_{(t+n)} = (\text{Factor})^n \times Q_{(t)}$$

Coefficient:

$$Q_{(t+n)} = e^{-\text{Coefficient}} \times Q_{(t)}$$

Time constant:

Time in days for the flow to drop to half its value

Connectors

Connectors allow this *Component* to be connected to others. River connectors can only be connected to other river type connectors and supply connectors only connected to other supply connectors. River connectors are circular; supply connectors are square. In-connectors are blue; out-connectors are red. In-connectors can only be connected to out-connectors. Similarly, out-connectors can only be connected to in-connectors.

Type	In/Out	Default number	Add	Remove
River	In	0	No	No
River	Out	1	No	No
Supply	In	0	No	No
Supply	Out	0	No	No
Supply (Demand Centre)	In	0	No	No

Properties

A *Component* only has one set of properties. Properties do not change during a model run.

Group	Name
Component	Display Name
	Draw order
Options	Show name
Schematic	Left
	Top
	Width
	Height
	Name X
	Name Y
	Angle
Draw	Line attributes
	Fill attributes
Shell	Caption
	Path
	Arguments
Info	Identifier
	Grid reference
	GIS reference
	Cross reference
	Owner
	Location
	Manager

Group	Name
	Other

Parameters

A *Component* can have more than one set of parameters. Parameters do not change during a model run.

Group	Name
Options	Animate on
	Enabled
	Events on
	Trace on
	Trace flags
Recession	Factor
	Coefficient
	Time constant
Prediction	Accuracy
Scaling	Catchment rainfall
	Catchment PET
	Catchment outflow
	Additional snowmelt
Flow output	Method

States

A *Component* can have more than one set of states. The value of a state variable may be different at the end of a model run to its value at the start.

There are no states for this type of *Component*.

Variables

A *Component* can have more than one set of variables. Variables are possible daily outputs from the *Component* and may be turned on and off.

Group	Name
Model input	Rainfall (1 – 3)
	PET (1 – 3)

Group	Name
	SW discharge (1 – 3)
	GW abstraction (1 – 3)
	Snow melt (1 – 3)
Flow	Recorded
	Model
Operation	Status level

Sequences

A *Component* can have more than one set of sequences. Sequences are a requirement, sometimes optional, of the *Component* for daily values of data. These data are supplied by a time series (potentially a different value every day) or a profile (series repeating annually).

Name	Time series	Profile
Recorded flow	Optional	Not used
Rainfall (1 – 3)	Required or	Required
PET ((1 – 3)	Required or	Required
Net discharge to surface water (1 – 3)	Optional	Optional
Net abstraction from groundwater (1 – 3)	Optional	Optional
Snowmelt (1 – 3)	Optional	Optional
Upstream flow (1 – 10)	Optional	Not used
Climate change – rainfall	Optional	Optional
Climate change – PET	Optional	Optional
Climate change – outflow	Optional	Optional

Recorded flow

A recorded (observed) flow sequence. Probably coming from the gauging station used in the calibration of the Catchment. This sequence is used by *HYSIM – calibration* as the flow sequence to calibrate against. It can also be used as source of flow data from the Catchment in a simulation (see parameter *Flow output.Method*).

Rainfall (1 – 3)

There can be up to three zones within a single Catchment, each with its own dataset. These three sequences are used to define the rainfall on each of the three zones. A sequence must be provided for dataset 1.

PET (1 – 3)

There can be up to three zones within a single Catchment, each with its own dataset. These three sequences are used to define the PET on each of the three zones. A sequence must be provided for dataset 1.

Net discharge to surface water (1 – 3)

There can be up to three zones within a single Catchment, each with its own dataset. These three sequences are used to define the net discharge to surface water into each of the three zones.

Net abstraction from groundwater (1 – 3)

There can be up to three zones within a single Catchment, each with its own dataset. These three sequences are used to define the net abstraction from groundwater in each of the three zones.

Snowmelt (1 – 3)

There can be up to three zones within a single Catchment, each with its own dataset. These three sequences are used to define the potential snowmelt in mm on each of the three zones.

Upstream flow (1 – 10)

There can be up to ten *upstream flow sequences* each with its own dataset. These ten sequences are used to define the inflow into the Catchment from external sources.

Climate change - rainfall

Climate change factors can be assigned to this sequence. These factors are applied to all rainfall data sets before being passed to HYSIM.

Climate change - PET

Climate change factors can be assigned to this sequence. These factors are applied to all PET data sets before being passed to HYSIM.

Climate change - outflow

Climate change factors can be assigned to this sequence. These factors are applied to only to flow values generated by the Catchment during a simulation that come from the recorded (observed) sequence. (They are not applied to the model flows as

it is assumed these will have been derived using the appropriate climate change factors on the rainfall and PET data).

Constraints

This *Component* does not have constraints attached.

Interfaces

An interface defines a fixed set of instructions to which the *Component* responds. During this response by the *Component*, it is possible for the VBA programmer to modify this response to customise the way model operates.

Name
IBaseObject
IFlowPredicted
IComponent
ISymbol
HYSIMModel.IAQTHYSIM

Resource State

This *Component* does not have a resource state.

Status level

If this *Component* generates a *missing* flow value, it reports an end of day status level of *Failure* (value = 2); otherwise the status returned is *OK* (value = 0).

Special Methods

Two publicly available methods are available to the VBA programmer for this *Component*:

1. *AddSWDischarge* (add water directly to the Catchment outflow)
2. *AbstractGW* (forces HYSIM's groundwater store to be depleted)

AddSWDischarge

An example of this might be for another *Aquator Component* (such as a Demand Centre) to add a surface water discharge to the HYSIM Catchment in which they were located. This would then be added to the daily flow generated by the HYSIM Catchment. An example of calling this method is:

HY1.AddSWDischarge Flow, DataSet

where:

HY1 = The HYSIM Catchment *Component* reference

Flow = The amount to add the surface water outflow

DataSet = The HYSIM data set to use. As HYSIM can have up to 3 data sets, **DataSet** must be in the range 1 – 3.

If the sequence *Net discharge to surface water (DataSet)* is defined for the *Component*, values of this sequence are increased by flow discharges added by this method.

AbstractGW

An example of this would be for one or more Aquator groundwater *Components* to apply a groundwater abstraction from the HYSIM Catchment in which they were located. This would then deplete the HYSIM Catchment's internal groundwater store and cause reduced river flows as a consequence in the days ahead. An example of calling this method is:

HY1.AbstractGW Flow, DataSet

where:

HY1 = The HYSIM Catchment *Component* reference

Flow = The amount to take from the groundwater store

DataSet = The HYSIM data set to use. As HYSIM can have up to 3 data sets, **DataSet** must be in the range 1 – 3.

If the sequence *Net abstraction from groundwater (DataSet)* is defined for the *Component*, values of this sequence are increased by abstractions added by this method.

Properties

A *Property* is a value for a *Component* which has no hydrological significance. For example, the co-ordinates of a *Component* on the schematic and the colours used to render the *Component*'s icon.

Arrow.Head, Arrow.Angle and Arrow.Size

If *Arrow.Head* is set to *True*, an arrow head is drawn, otherwise it is not.

Arrow.Angle determines the angle of the arrow lines to that part of the *Component* containing the line.

Arrow.Size specifies the length of the arrow lines.

Component.Display name

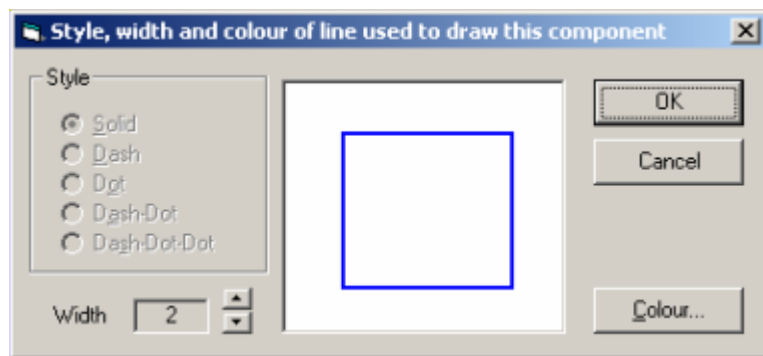
The name that appears on the schematic and other output. This name may be changed.

Component.Draw order

Reserved for future use.

Draw.[Line attributes]

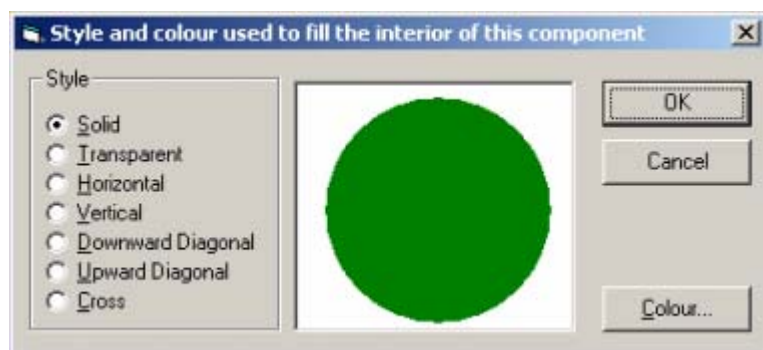
[Line attributes] may be replaced with a more specific name such as *Draw.Reach attributes*. The line drawing is defined by selecting this property and clicking on the [...] button. The following dialog box is displayed;



Note that, in common with many other Windows applications, it is not possible to specify a *Style* other than solid with a line *Width* greater than 1.

Draw.[Fill attributes]

[Fill attributes] may be replaced with a more specific name such as *Draw.Fill attributes 2*. The fill attributes are defined by selecting this property and clicking on the [...] button. The following dialog box is displayed:



Draw.Font

Any Windows screen font available on the system. A standard font selection dialogue box is displayed to enable font selection.

Draw.Shape

Shape the object is to take. For example, rectangular or circular.

Draw.Text

Any single line text string.

Info.Identifier, Info.Grid Reference, Info.GIS Reference, Info.Cross Reference, Info.Owner, Info.Location, Info.Manager, Info.Other,

Each of these properties is a single line of text that can be used for additional description of the component. The text could be for internal use for annotating a component. Alternatively it could be used by external applications using Aquator automation interface. An example would be a GIS package retrieving GIS co-ordinates from the *Info.GIS Reference* property.

Options.Show name

If set to *True*, the name is shown on the schematic. This option must also be set to *True* to enable numerical animation of the Component during a model run.

Schematic.Left, Schematic.Top, Schematic.Width and Schematic.Height

The position (*Left, Top*), relative to the Top Left Hand corner, and size (*Width, Height*) of the Component on the schematic.

Schematic.Name X, Schematic.Name Y, and Schematic.Name Angle

The position of the Component name (*Name X, Name Y*), relative to the position of the Component.

Name Angle is reserved for future use.

Shell.Caption, Shell.Path, and Shell.Arguments

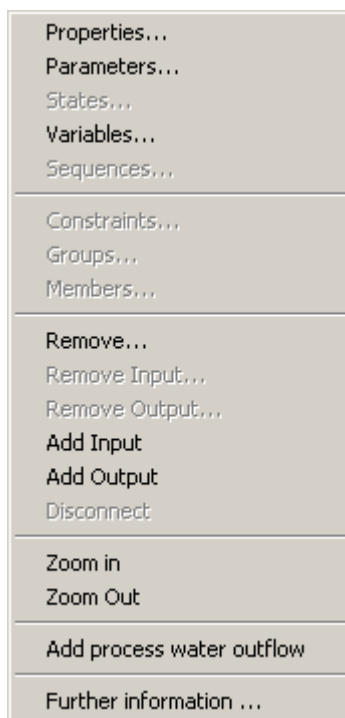
These three properties allow each Aquator Component to be linked to an external application.

For example, it would be possible to link a Water Treatment Works to the appropriate record in an Access database.

The second application is invoked by clicking the right mouse on the schematic, and selecting the appropriate item from the pop-up menu.

If *Shell.Caption* and *Shell.Path* are non blank, an item is appended to the pop-menu item for that Component.

For example if *Shell.Caption* = "Further information...", the pop-up menu might look like:



Shell.Path must be set to the name of the application that is to be started. For example:

C:\Program Files\Microsoft Office\Office\MSACCESS.EXE

Shell.Arguments is optionally set to command line arguments of the second application. Continuing the example of the Access database. this might be the name of the database to open and name of macro to run after the database is loaded:

"C:\Aquator\Database\Aquator.mdb" /X WTW4

Parameters

A *Parameter* is a value for a Component which affects its behaviour during a model run, but which typically does not change during a run, and often is not changed between runs. For example: the stage-area-volume curves of a Reservoir Component would not normally be altered frequently.

Flow output.Method

This parameter determines the source of the daily flow produced by HYSIM Catchment in simulation mode. One of three options are possible:

1. Recorded flow only (no model flows are used)
2. Model flow only (no recorded flows are used)
3. Recorded in-filled with model. Flow is first taken from the recorded series. If this is missing on any day, the HYSIM model flow is used. Note that in this model HYSIM simulation takes place on every day, even if the flows are not used, to keep HYSIM's internal states up to date.

Options.Animate on

Set to *True* if the Component is to provide day by day animation as the model runs. An example of this is a Reservoir which can show its current storage state each day by graphically on the schematic.

Model execution time is increased when this option is on.

Operation.Demand saving

If set to *True* this Group will communicate its demand saving level with Aquator.

Options.Enabled

When enabled the Group operates normally. Setting this option to *False* effectively removed the Group from the system during model execution. It is recommended that if one or more Groups are disabled, the model log is inspected to check the water balance.

Options.Events on

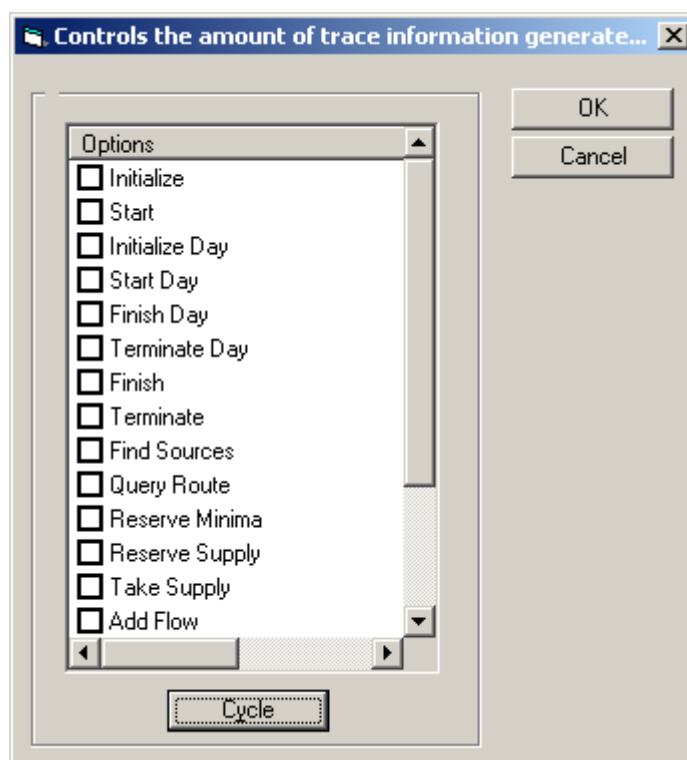
When set to *True* any Visual Basic (VBA) code attached to the Group will be executed. If you have no VBA code then it is a good idea to set this option to *False* as this will improve model performance.

Options.Trace on

When set to *True*, Group events are logged in the *Trace log*. This is useful when debugging a system to ensure it is behaving as required. It is more efficient in terms of model execution time to have this option set to *False*

Options.Trace flags

This option allows the trapping of specific events during a model run on a Group by Group basis. The following dialog box is displayed to allow the events to be specified:



Prediction.Accuracy

This parameter is used in the forecasting of future flows and is described under the *HYSIM catchment* component.

Recession.Coefficient

This parameter is used in the forecasting of future flows. It is related to parameters *Recession.Factor* and *Recession.Time constant* and described under the *HYSIM catchment* component.

Recession.Factor

This parameter is used in the forecasting of future flows. It is related to parameters *Recession.Coefficient* and *Recession.Time constant* and described under the *HYSIM catchment* component.

Recession.Time constant

This parameter is used in the forecasting of future flows. It is related to parameters *Recession.Coefficient* and *Recession.Factor* and described under the *HYSIM catchment* component.

Scaling.Catchment rainfall

A single scaling factor which is applied to all values of daily rainfall before that value is passed from Aquator to both HYSIM calibration and HYSIM simulation.

Scaling.Catchment PET

A single scaling factor which is applied to all values of daily PET before that value is passed from Aquator to both HYSIM calibration and HYSIM simulation.

Scaling.Catchment outflow

A single scaling factor which is applied to all values of daily flow produced by the model during simulation. Both model and recorded flows are scaled.

Scaling.Additional snowmelt

An additional amount of potential snowmelt (in mm) that is to be added to each daily value of the *Snowmelt* data that is passed from Aquator to both HYSIM calibration and HYSIM simulation

States

A value for a Component which affects its behaviour during a model run, and which typically does change during the run, and often is changed between runs. For example: the initial storage of a Reservoir on the first day of the run would typically vary from run to run.

Variables

A value for a Component which is computed daily during a model run. This can include both predicted and observed values i.e. a sequence of observed storage linked to a Reservoir Component can be captured in a variable so that both observed and calculated storage can be plotted on the same chart.

Flow.Model

Flow as modelled by HYSIM rather than flow recorded or observed in the field.

Flow.Recorded

The recorded (observed) flow.

Model input.Rainfall (1 – 3)

A plot of rainfall passed to HYSIM for each of the three possible data sets. This series reflects the scaling applied to the rainfall through the parameter *Scaling.catchment rainfall* and the climate change sequence *Climate change – rainfall*.

Model input.PET (1 – 3)

A plot of Potential Evapo-transpiration (PET) passed to HYSIM for each of the three possible data sets. This series reflects the scaling applied to the PET through the parameter *Scaling.catchment PET* and the climate change sequence *Climate change – PET*.

Model input.SW discharge (1 – 3)

A plot of additional surface water discharge passed to HYSIM for each of the three possible data sets. This series includes any additional surface water discharge added by the VBA programmer using the method *AddSWDischarge*.

Model input.GW abstraction (1 – 3)

A plot of additional groundwater abstraction passed to HYSIM for each of the three possible data sets. This series includes any additional groundwater abstraction added by the VBA programmer using the method *AbstractGW*.

Model input.Snow melt (1 – 3)

A plot of potential snowmelt passed to HYSIM for each of the three possible data sets. This series includes the additional snowmelt supplied in the parameter *Scaling.Additional snowmelt*.

Operation.Status level

The status level reported by this Component at the end of the day. Status level can be one of the following:

Level	Description
0	OK
1	Warning
2	Failure
3	Error

Sequences

A sequence is a requirement for daily data during a model run. Sequential data must be supplied to a Component in order for the Component to operate correctly. For example, a Reservoir requires a rainfall sequence to compute water added by precipitation each day.

The type of sequence available is particular to each Component.