A Guide to Aquator

# 2 Components

Version 4.2

**Oxford Scientific Software Ltd**

# Contents

# Components

## What is a Component?

Components in Aquator are the basic elements of the Water Resource Model e.g. Abstraction, Catchment, Confluence etc. Any number of components may be included in the model by dragging the Component from the Component toolbox and dropping on the schematic.

Standard components may be joined together by using the Link or any other component which has just two connectors joined by a line. The ends of such components can be dragged and dropped onto other connectors to make a join.

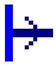
Each Component has a set of attributes: *Properties*, *Parameters*, *States*, *Variables* and *Sequences* which make up the input and output data, and built-in operating rules which define how the Component behaves in the Model.

## Standard Components

The following is a list of the standard Aquator components.

- Abstraction
- Bi-Directional Link
- Blender
- Bulk Supply
- Catchment
- Combiner
- Confluence
- Constraint Holder
- Demand Centre
- Discharge
- Diversion
- Gauging Station
- Groundwater
- Hydro-Generator
- Join
- Link
- Pump Station
- Reach
- Regulator
- Reservoir
- Service Reservoir
- Split
- Termination
- Water Treatment Works

## Abstraction



An Abstraction allows water to be taken from a river to supply. There are two fundamentally different ways this can occur and neither, either, or both can be enabled.

The abstraction can simply pass the demand up-river to another supply via an upstream *Regulator component*. This is called *indirect* abstraction because it does not decrease the flow below the Abstraction. Therefore flow constraints at or below the Abstraction component do not affect whether such demands can be met or not.

Conversely, *direct* abstraction takes water directly from the river and thereby reduces the river flow below the Abstraction component. Therefore flow constraints at and below the Abstraction will affect how much water can be taken.

*Direct* abstraction does not preclude an upstream regulator adding water to the river earlier in the day. Thus a Regulator can increase the river flow and, later, an Abstraction can reduce the flow. This is still *direct* abstraction because the demand is *not* simply routed up-river as in the case of *indirect* abstraction.

Abstraction components (and Gauging Station components) can be setup to implement a flow constraint on *direct abstraction* in one of three ways:

1. **None**. All available water can be abstracted from the river.
2. **Maintained flow**. Abstraction can take place while the river flow downstream of the abstraction is at or above the flow constraint value. Earlier in the day upstream regulators may have added water to the river to meet these maintained flow constraints but at the point of abstraction no account is taken of whether this was done or not. The rule is simply that the downstream flow must not fall below the maintained flow value *due to abstraction at the time the abstraction is made*. If the river flow is below this value then no water is availablefor *direct* abstraction (as described earlier, *indirect* abstraction is not constrained by maintained flow constraints).
3. **Prescribed flow**. This is similar to the maintained flow case but relaxed by taking into account whether water has been added by upstream regulators earlier in the day. Abstraction can take place while the river flow downstream of the abstraction is at or above the flow

constraint value or the natural flow, whichever is less. This implies that water added to the river by an upstream regulator can be abstracted even if the river flow then falls below the flow constraint value, as long as the natural flow is not reduced below what it would have been with no abstraction. Upstream regulators will not add water to meet a prescribed flow value, they (optionally) only add water to meet the expected demand and any maintained flow constraints. Again, prescribed flow constraints only affect *direct* abstraction, not *indirect* abstraction.

The amount that can be taken depends on

1. The upstream flow
2. Any releases made to support direct abstraction
3. The amount of water that must be left downstream of the Abstraction; this might be due to a flow constraint at the Abstraction itself or a flow constraint further downstream, for example at a Gauging Station component.
4. The demand at the abstraction
5. Restrictions at the Abstraction site. These restrictions are parameter values such as daily and monthly maximum values. They also include constraints on the abstraction itself or any groups to which the abstraction belongs.

### *Flow constraint*

The flow constraint value on any day is taken from either a fixed value or a sequence. The parameter *Flow constraint.Use sequence* determines this source.

If set to *True*, the value of flow constraint is taken from a time series if assigned; otherwise from the assigned profile. If neither a time series or a profile are assigned, a flow constraint of zero is used.

If set to *False*, the flow constraint is taken from the parameter *Flow constraint.Value*.

### *Restrictions at the abstraction site*

The amount that can be abstracted on any day can be optionally controlled by a sequence. This sequence value (if any) is capped at the maximum daily Abstraction and further capped by the current monthly maximum Abstraction rate.

### *Type of abstraction*

As stated above there can be two types of abstraction from the river *direct* and *indirect Direct* abstractions can take only water that is currently available in the river above any flow constraint. *Indirect* abstractions look upstream for one or more *regulator* *components* and request water from sources attached the regulator. Both types of abstraction can take place on the same abstraction as determined by the parameters *Operation.Allow direct abstraction* and *Operation.Allow indirect abstraction*. If both parameters are set to True, demand is met by using the direct abstraction first and the indirect only if then required. This behaviour can be changed by using VBA to set the route order on the demand centre's *PrioritizeRoutes* event.

## 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 | 1 | No | No |
| River | Out | 1 | No | No |
| Supply | In | 0 | No | No |
| Supply | Out | 1 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |

| Group | Name |
|---|---|
| | Angle |
| Draw | Fill attributes |
| | Outline attributes |
| | Reach attributes |
| | Outlet attributes |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Forecasting on |
| | Diagnostics on |
| | Trace on |
| | Trace flags |
| Operation | Allow direct abstraction |
| | Allow indirect abstraction |
| Control flow | Type |
| | Value |
| Flow constraint | Type |
| | Value |
| | Use sequence |

| Group | Name |
|---|---|
| | Report failure |
| | Safety margin |
| | Failure margin |
| Percentage take | Above flow constraint |
| | Only apply locally |
| Check downstream | Maximum flow constraints |
| | Maximum delay |
| Upstream releases | Minimum delay |
| | Maximum delay |
| | Prediction method |
| | Prediction amount |
| | Prediction scale factor |
| Abstraction | Enforce maximum |
| | Daily max |
| | Month 1 (Jan) max |
| | Month 2 (Feb) max |
| | Month 3 (Mar) max |
| | Month 4 (Apr) max |
| | Month 5 (May) max |
| | Month 6 (Jun) max |
| | Month 7 (Jul) max |
| | Month 8 (Aug) max |
| | Month 9 (Sep) max |
| | Month 10 (Oct) max |
| | Month 11 (Nov) max |
| | Month 12 (Dec) max |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |
| Leakage flows | Enforce limit |
| | Reservation limit |
| Minimum flows | Enforce limit |
| | Reservation limit |
| Demand minima | Enforce limit |
| | Reservation limit |
| | Scaling factor |

## 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. States are described at the end of this Chapter.

| Group | Name |
|---|---|
| Yesterdays | Abstraction |
| | Demand |
| | Supply per AO |
| | Supply per RO |

## 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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Flow | Upstream |
| | Downstream |
| | Natural |
| | Constraint |
| Supply | Direct pass 1 |
| | Direct pass 2 |
| | Direct pass 3 |
| | Direct pass 4 |
| | Direct pass 5 |
| | Direct pass 6 |
| | Direct |
| | Indirect |
| | Amount |
| | Maximum abstraction |
| | Cost |
| Operation | Control flow |
| | Resource state |
| | Status level |
| | Failure amount |

### 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Maximum abstraction | Optional | Optional |
| Control flow | Optional | Optional |
| Flow constraint | Optional | Optional |
| Cost per Ml | Optional | Optional |

### Constraints

This Component can have constraints attached.

### Groups

This Component can be included in an Abstraction group.

### 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 |
| ISupply |
| IFow |
| IFlowPredicted |
| IComponent |
| IDemand |
| IResource |
| IGroupMember |
| IAbstractionData |
| ISymbol |

### Resource State

An Abstraction component can determine its resource state in one of three ways:

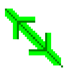
1. **Last abstraction**. This method uses the Abstraction made yesterday to determine its resource state today. If the amount of water available today above the flow constraint is greater than yesterday's Abstraction, the resource state for the day is set greater than 1. If today's available water is less than yesterday's Abstraction, the resource state is less than 1.
2. **Parameter value**. This method uses the current upstream flow and compares this against the value set in parameter *Control flow.Value*. Resource state is the current flow divided by the parameter value. If the parameter value is set to zero in this method, this has the effect of creating an unlimited resource state making all water from this source available on Pass 4.
3. **Sequence value**. This method is similar to the "Parameter value" method above except the control flow comes form the time series or profile attached to the *Control flow* sequence.

The parameter Control flow.Type determines which of the above three methods is to be used.

### Status level

The Abstraction component reports an end of day status level of *OK* (value = 0) unless there has been an Abstraction and the parameter *Flow constraint.Type* is set to "Prescribed flow" the downstream flow is less than the flow constraint and the parameter *Flow constraint.Report failure* is set to True. In this case a status level of *Failure* (value = 2) is reported. This condition should not occur under normal operation of the component. It could occur as a result of user modified behaviour with VBA.

## Bi-Directional Link



A bi-directional link is located in the supply network and allows water to flow in a different direction each day. The choice of direction choosing algorithm is made by setting parameter *Direction.Algorithm* to one of the following

1. **None** – The direction will be fixed for the duration of the run to that set in the state *Flow direction.Current value*. Use this option if the direction needs to be fixed for the current run. This option may also be used if VBA code is setting the direction each day.

2. **Alternate** – The direction will switch every 'n' days where 'n' is defined in the state *Flow direction.Hold period*. The state *Flow direction.Days since reversal* is used to determine when the first switch of direction in a model run is to take place.
3. **Best Resource State** – Each day the direction is chosen so that flow is away from the source which has the best resource state.
4. **Mean Resource State** – Each day the direction is chosen so that flow is away from the sources which have the best mean resource state.
5. **Lowest Cost** – Each day the direction is chosen so that the cheapest route will be used.
6. **Mean Cost** – Each day the direction is chosen so that the routes with the lowest mean cost will be used.

Alternatively the direction can be set each day in VBA code by programming the 'ChooseDirection' event as illustrated by the following example:

```
Private Sub BiDiLink_ChooseDirection(ByVal Timestamp As Date, ByVal Step As Long, _
                                     ByVal OldDirection As AQTComponents.aqtDirection, _
                                     NewDirection As AQTComponents.aqtDirection)

  ' Set the direction today in this event to one three possible enumerated values:
  ' (aqtDirectionForward, aqtDirectionReverse or aqtDirectionUnchanged)
  If Month(Timestamp) < 6 Then
    NewDirection = aqtDirectionForward

  ElseIf Month(Timestamp) > 8 Then
    NewDirection = aqtDirectionReverse

  Else
    NewDirection = aqtDirectionUnchanged

  End If

End Sub
```

Bi-directional links need to be joined to the rest of the supply network using bi-directional connectors. This may be achieved by converting the bi-directional connector may to a supply type in-connector and a supply type out-connector using the *Combiner* component. Alternatively it is possible to add bi-directional connectors directly to some components (e.g. *Reservoir* and *Service Reservoir*).

## 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 | 0 | No | No |
| Supply | In | 0 | No | No |
| Supply | Out | 0 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 2 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Line attributes |
| Arrow | Head |
| | Angle |
| | Size |
| Shell | Caption |

| Group | Name |
| --- | --- |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

### Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| Direction | Algorithm |
| Cost | Fixed cost - forward |
| | Fixed cost - reverse |
| | Cost per Ml - forward |
| | Cost per Ml - reverse |
| | Weighting - forward |
| | Weighting - reverse |
| Limits | Enforce max flow |
| | Max flow - forward |
| | Max flow - reverse |
| | Enforce min flow |
| | Min flow - forward |
| | Min flow - reverse |
| Warning | Min flow |
| Leakage | Link length |

| Group | Name |
|---|---|
| | Loss rate - forward |
| | Loss rate - reverse |
| | Leak at zero flow - forward |
| | Leak at zero flow - reverse |

### 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. States are described at the end of this Chapter.

| Group | Name |
|---|---|
| Flow direction | Current value |
| | Hold period |
| | Days since reversal |

### 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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Flow | Direction |
| Inflow | Forward |
| | Reverse |
| | Forward - Reverse |
| Outflow | Forward |
| | Reverse |
| | Forward - Reverse |
| Supply | Cost |
| Leakage | Amount |
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Forward cost per Ml | Optional | Optional |
| Reverse cost per Ml | Optional | Optional |

### Constraints

This Component cannot have constraints attached.

### Groups

This Component cannot be included in a group.

### 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 |
| IComponent |
| ISupply |
| ISymbol |

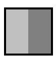
### Resource State

This Component does not have a resource state of its own.

### Status level

If the minimum flow is not met and the parameter *Warning.Min flow* is set to true, this Component type always report an end of day status level of *Warning* (value = 1). Otherwise the end of day status level is set to *OK* (value = 0)

## Blender



A Blender is located in the supply network and has a minimum of two inputs and one output. Each input has a defined water quality and the blender's job is to mix the inputs in such a way as to ensure the output water quality is within defined limits.

Each input to the blender should be connected to just one source of supply and normally each supply should have one or more licences which constrain the maximum flows at each input.

Each Blender supports multiple user-defined determinands. It is the task of the blender to keep the determinand levels in the output water below specified levels. If this cannot be achieved then the blender delivers no water.

There are four blending methods:

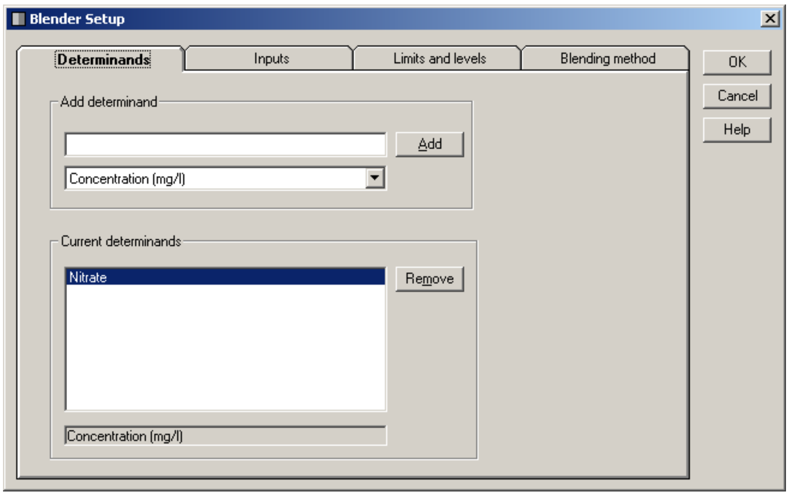
1. **Fixed ratios** – Blends using fixed ratios. Does not attempt to keep the determinand levels in the outflow below set limits.
2. **Least cost** – Minimises the cost of water supplied with the constraint that no determinand limit is exceeded.
3. **Best resource state** – Maximises the use of supplies with the best resource state with the constraint that no determinand limit is exceeded.
4. **Optimal** – Minimises the cost of water supplied when excess water is available, otherwise maximizes the use of supplies with the best resource state, both subject to the constraint that no determinand limit is exceeded.

If one of the last three methods is chosen then the blender executes the so-called simplex algorithm to minimize or maximize the chosen quantity subject to the following conditions:

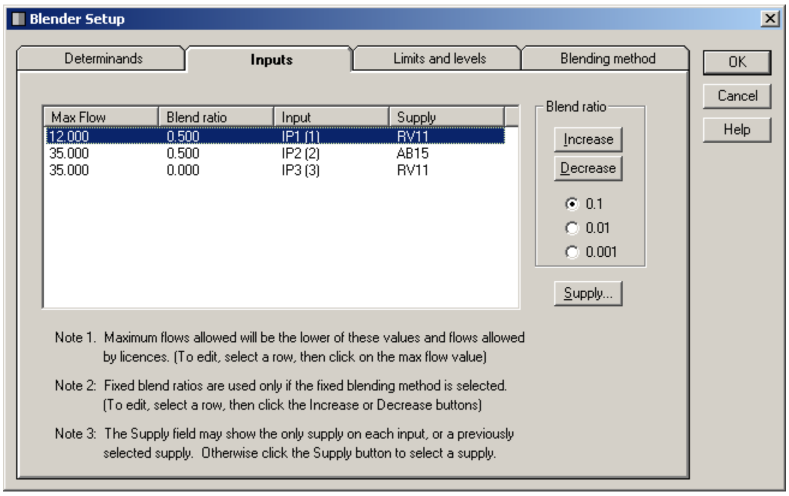
- the demand is met – the sum of the input flows must equal the demand
- the maximum flow at each input is not exceeded – normally determined by licences on each supply, otherwise by maximum flow parameters specified for each input
- the level of each determinand in the output water does not exceed the specified limit for that determinand

This algorithm can fail because demand cannot be met. In this eventuality the simplex algorithm is re-applied with the goal of maximizing the amount of water that can be supplied. In the worst case the amount that can be supplied is simply zero.

There is special setup form for the Blender which assists with setting the various parameters and options. The form is available by right clicking on the blender and selecting the “Blender setup…” menu item. The form has four tabs.




The first tab of allows the determinands at this Blender to be defined. There can be any number of these, simply defined by entering a name, choosing the units, and clicking "Add".



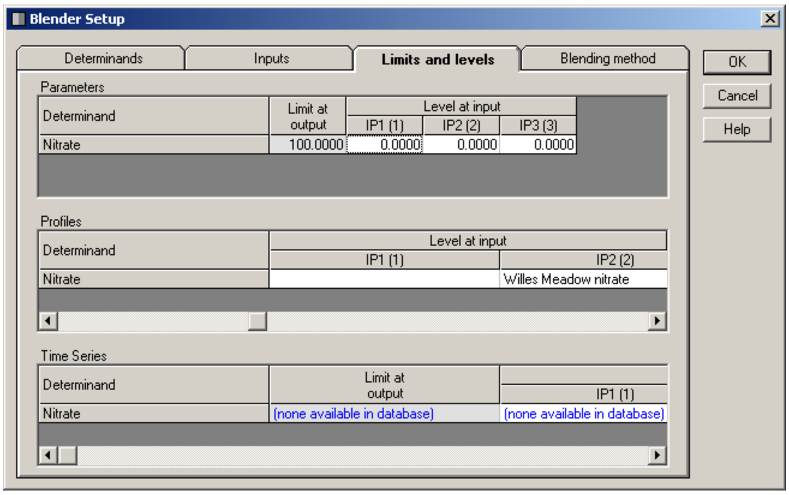

The second tab allows the inputs to be set up. Each input should have a “Max flow” value set which informs the blender of the absolute maximum amount that can arrive at each input. Click on the value to edit.

Normally the supply on each input should have a licence and it is this licence that determines the maximum flow at each input. The maximum flow values set by this dialog are then redundant and should be set higher than any possible licensed value. But if the supplies have no licences then these are the maximum flows that will be used.

The "Blend ratio" values in the second column on this tab are set using the buttons in the "Blend ratio" box. These values are used

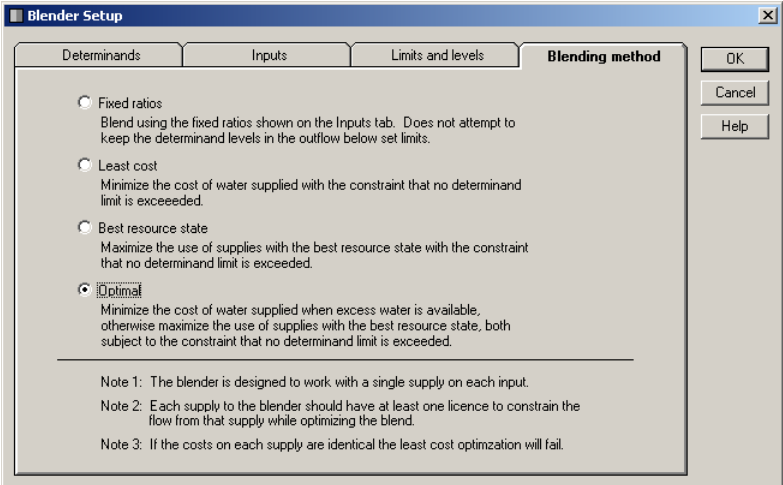
(a) to apportion any demand minima reserved ahead at the start of a model run, and (b) if the **Fixed Ratio** blend method is selected (fourth tab).

The third column names the input for identification purposes and the fourth column defines the source. If there is only one source on an input then identification is automatic. If there are multiple sources on each input, the source for blending can be selected using the “Supply…” command button on the right of the window. The blender will only use water from one supply on each input.




The third tab allows the output limits and input levels of each determined to be defined. These may be supplied as parameter values if they are fixed quantities or as profiles or as full time series.

The blender will use a time series value if a time series is specified, else a profile value if a profile is specified, else the parameter value. Similarly if the time series was specified but the value on any day is missing.




The last tab, shown below, allows the blending method to be specified. The four possible blending methods are described above.

## 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 | 0 | No | No |
| Supply | In | 2 | Yes | Yes |
| Supply | Out | 1 | Yes | Yes |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| 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 - left |
| | Fill attributes - right |
| | Fill attributes - failure |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Diagnostics on |
| | Trace on |
| | Trace flags |
| Blender | Method |
| | Failure margin |
| | Report failures |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |
| Demand minima | Enforce limits |
| | Reservation limits |
| | Scaling factor |
| Determinand limit [1] | Determinand 1 |
| | Determinand 2 … etc |
| Determinand level [1] [2] | Determinand 1 |
| | Determinand 2 … etc |
| Flow [2] | Maximum |
| Supply [2] | Name |
| Blend [2] | Fraction |

[1] These appear red in the edit forms because they are not built-in parameters but are added by the user, with the *Blender Setup* dialog described above, in the same way as parameters added to any component using VBA. Therefore they may be removed, using the same dialog, whereas built-in parameters are shown in black text and cannot be removed.

Note that text "Determinand 1" etc. will be replaced by the actual name of the determinand, e.g. "Nitrate".

[2] Located on each input connector, right click on the connector rather than the component to see the parameter.

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Supply | Amount pass 1 |
| | Amount pass 2 |
| | Amount pass 3 |
| | Amount pass 4 |
| | Amount pass 5 |
| | Amount pass 6 |
| | Amount |
| | Cost |
| Operation | Blend result |
| | Status level |
| Determinand limit [1] | Determinand 1 |
| | Determinand 2… |
| Determinand level [1] | Determinand 1 |
| | Determinand 2 … etc |
| | Determinand 1 (% of limit) |
| | Determinand 2 (% of limit) … etc |
| Connector [2] | Flow |
| | Maximum flow |
| | Blend fraction |
| Determinand level [1 2] | Determinand 1 |
| | Determinand 2 … etc |

[1] These appear red in the edit forms because they are not built-in parameters but are added by the user, with the *Blender Setup* dialog described above, in the same way as parameters added to any component using VBA. Therefore they may be removed, using the same dialog, whereas built-in parameters are shown in black text and cannot be removed.

Note that text "Determinand 1" etc. will be replaced by the actual name of the determinand, e.g. "Nitrate".

[2] Located on each input connector, right click on the connector rather than the component to see it.

## 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Cost per Ml | Optional | Optional |
| Determinand 1 limit [1] | Optional | Optional |
| Determinand 2 … etc | | |
| Determinand 1 level [1,2] | Optional | Optional |
| Determinand 2 … etc | | |

[1] These appear red in the edit forms because they are not built-in parameters but are added by the user, with the *Blender Setup* dialog described above, in the same way as parameters added to any component using VBA. Therefore they may be removed, using the same dialog, whereas built-in parameters are shown in black text and cannot be removed.

Note that text "Determinand 1" etc. will be replaced by the actual name of the determinand, e.g. "Nitrate".

[2] Located on each input connector, right click on the connector rather than the component to see it.

## Constraints

This Component cannot have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IComponent |

| Name |
| --- |
| ISupply |
| IResource |
| ISymbol |

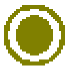
### Resource State

This Component does not have a resource state of its own.

### Status level

If any determinand output limit is exceeded this Component type reports an end of day status level of *Warning* (value = 1) unless the parameter Blender.Report failures is True, when a *Failure* (value = 2) is reported. A warning can also be reported if the resource state of any supply was required but was invalid. Otherwise the end of day status level is set to *OK* (value = 0)

## Bulk Supply



A Bulk Supply acts as a source of water and can be used to represent a transfer of water from outside to the current model. The amount that is available for supply each day is taken according to the priority:

1. Time series if assigned
2. Profile if assigned
3. Fixed parameter value

If the parameter *Supply.Must use entire amount* is set to True, the bulk supply will try to ensure that its available water is used to the full. If set to False, then the bulk supply is handled in the same way as any other source.

## 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 | 0 | No | No |
| Supply | In | 0 | No | No |
| Supply | Out | 1 | Yes | Yes |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| 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 |
| Arrow | Head |
| | Angle |
| | Size |

| Group | Name |
|---|---|
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| Supply | Amount |
| | Must use entire amount |
| | Failure margin |
| | Report failures |
| Control flow | Type |
| | Value |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |
| Leakage flows | Enforce limit |
| | Reservation limit |
| Minimum flows | Enforce limit |
| | Reservation limit |
| Demand minima | Enforce limit |

| Group | Name |
| --- | --- |
| | Reservation limit |
| | Scaling factor |

## 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. States are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Yesterdays | Supply<br>Supply per AO<br>Supply per RO |

## 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. Variables are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Supply | Amount pass 1 |
| | Amount pass 2 |
| | Amount pass 3 |
| | Amount pass 4 |
| | Amount pass 5 |
| | Amount pass 6 |
| | Amount |
| | Available |
| | Cost |
| Operation | Control flow |
| | Resource state |
| | Status level |
| | Failure amount |

## 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Amount to supply | Optional | Optional |
| Control flow | Optional | Optional |
| Cost per Ml | Optional | Optional |

## Constraints

This Component cannot have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IComponent |
| ISupply |
| IResource |
| ISymbol |

## Resource State

A Bulk Supply component determines its resource state from the control flow.  If the *Control flow.Type* specifies the sequence is to be used then the value is taken from the time series, if specified, otherwise from the profile. If the value is missing then the control flow is set to zero.

Otherwise the *Control flow.Value* parameter is used if the Control flow.Type specifies the parameter is to be used, else the control flow is zero.

If the control flow is zero then the resource state is invalid. Effectively this means an infinite resource state and implies that all available water can be used on pass 4 (excess pass).

Otherwise the resource state equals the amount available divided by the control flow value. Effectively the Bulk Supply can be "drawn down" on pass 4 until an amount equal to the control flow is left. This amount can be used on pass 5 if necessary.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Catchment

A Catchment marks the start of one branch of the river network and adds water on daily basis to the river network at that point.

The amount of water that is added is defined by a sequence. This sequence can be either a time series or a profile. It is obligatory for at least one of these to be specified.

The daily value can be modified by both:

1. A fixed scaling parameter (Flow.Scaling)
2. Climate change factors specified as a sequence

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 the time series (or profile) defining the catchment’s flow. This is 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.
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: $Q_{(n+1)} = \text{Factor} \times Q_{(n)}$

Coefficient: $Q_{(n+1)} = e^{-\text{Coefficient}} \times Q_{(n)}$

Time constant: $Q_{(n+1)} = e^{-1/\text{TimeConstant}} \times Q_{(n)}$

## 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 |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| 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 |

| Group | Name |
|---|---|
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| Flow | Offset |
| | Scaling |
| Recession | Factor |
| | Coefficient |
| | Time constant |
| Prediction | Accuracy |

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Flow | Amount |
| | Climate change scaling |
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Flow | Required or | Required |
| Climate change | Optional | Optional |

## Constraints

This Component does not have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
|---|
| IFlowPredicted |
| IBaseObject |
| IComponent |
| ISymbol |

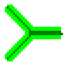
## Resource State

This Component does not have a resource state.

## Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

# Combiner



A Combiner converts a supply type in-connector and a supply type out-connector to a supply type bi-directional connector. A combiner component may therefore be used to connect a *Bi-directional Link* component to the rest of the supply network.

## 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 | 0 | No | No |
| Supply | In | 1 | No | No |
| Supply | Out | 1 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 1 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |

| Group | Name |
| --- | --- |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Fill attributes |
| | Outline attributes |
| | Line attributes |
| Arrow | Head |
| | Angle |
| | Size |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |

| Group | Name |
|---|---|
| | Trace flags |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Main | Inflow |
| | Outflow |
| Bidirectional | Inflow |
| | Outflow |
| | Net flow |
| Supply | Cost |
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Cost per Ml | Optional | Optional |

## Constraints

This Component cannot have constraints attached.

### Groups

This Component cannot be included in a group.

### 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 |
| IComponent |
| ISupply |
| ISymbol |

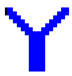
### Resource State

This Component does not have a resource state of its own.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Confluence



A confluence combines two input river reaches into a single output river reach.

### 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 | 2 | No | No |
| River | Out | 1 | No | No |
| Supply | In | 0 | No | No |

| Type | In/Out | Default number | Add | Remove |
|---|---|---|---|---|
| Supply | Out | 0 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Line attributes |
| | Outline attributes |
| | Fill attributes |
| Arrow | Head |
| | Angle |
| | Size |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |

| Group | Name |
| --- | --- |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| | Anabranch detection |

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Flow | Inflow1 |
| | Inflow2 |
| | Outflow |
| Operation | Status level |

## Sequences

There are no sequences for this type of Component.

## Constraints

This Component does not have constraints attached.

### Groups

This Component cannot be included in a group.

### 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 |
| IFlow |
| IFlowPredicted |
| ISupply |
| IComponent |
| ISymbol |

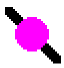
### Resource State

This Component does not have a resource state.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Constraint holder



A constraint holder joins together supply type components in the same way as a *Link*. Apart from its *Limits.Max flow* parameter, a constraint holder itself does not limit or control flow in the supply distribution network. However constraints (such as licences) may be placed on the this type of component which do limit flow.

One use of a constraint holder is to allow a single source (such as a reservoir or groundwater) to have multiple abstractions each with different licences. An annual licence, for example, placed on a reservoir would control all abstractions from that reservoir; whereas as an annual licence placed on a constraint holder connecting the reservoir to a one demand would only control that abstraction.

## 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 | 0 | No | No |
| Supply | In | 1 | No | No |
| Supply | Out | 1 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Fill attributes |
| | Line attributes |
| Arrow | Head |
| | Angle |

| Group | Name |
|---|---|
| | Size |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| Limits | Max flow |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Supply | Amount |
| | Cost |
| Operation | Resource state |
| | 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Cost per Ml | Optional | Optional |

## Constraints

This Component can have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IComponent |
| ISupply |
| ISymbol |

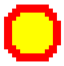
### Resource State

This Component does not have a resource state of its own but takes the value of the minimum resource state of any valid resource state reported by its constraints.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Demand Centre



A Demand Centre acts as source of demand. There is always at least one supply type in-connector located on a Demand Centre. Additional in-connectors can be added to allow the Demand Centre to receive water from other sources.

Demand Centre in-connectors are a special type of supply connector. Individually they allow a minimum quantity of water that must enter the Demand Centre by that route to be specified. This to allow for the fact that in practice it might only be possible to supply a certain part of the area covered by the Demand Centre by water entering by a specific route.

Demand centres instigate the movement of water in the supply network, requesting water from each of its possible sources as required.

Daily demand is taken from the sequence *Demand sequence* as a value in Ml/d if either a time series or a profile has been assigned.

If there is no time series or profile assigned to the sequence *Demand sequence*, demand is taken from the parameter *General.Demand*. If the *Demand factor* sequence profile is assigned, the fixed value of demand provided by the parameter is multiplied by the value of the sequence to give the demand for the day.

Finally the demand, by whatever route it has been established, is multiplied by the parameter *General.Demand factor*.

Any number of river type out-connectors may be added to a Demand Centre. These out-connectors each have a parameter *General.Percent return* which sets the percentage of the amount supplied to the Demand Centre that is returned to the river system (*Effluent return*).

If supply fails to meet demand on any day, the Component indicates this on the schematic by changing colour if the option to animate is turned on.

## 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 | 0 | Yes | Yes |
| Supply | In | 0 | No | No |
| Supply | Out | 0 | No | No |
| Supply (Demand Centre) | In | 1 | Yes | Yes (1 min) |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| 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 |
| | Fill attributes – failure |
| Shell | Caption |

| Group | Name |
|---|---|
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

### Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Diagnostics on |
| | Trace on |
| | Trace flags |
| Component | Advance order |
| | Demand order |
| General | Demand |
| | Demand factor |
| | Apply demand saving |
| | Percent return [2] |
| | Return is natural flow [2] |
| Fail | If demand not met |
| | Criterion |
| Minimum supply | Use profile [1] |
| | Constant value [1] |

[1] Located on each DC supply in-connector, right click on the connector rather than the component to see it.

[2] Located on the river type out-connector, right click on the connector rather than the component to see it.

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Demand | Amount |
| Supply | Amount pass 1 |
| | Amount pass 2 |
| | Amount pass 3 |
| | Amount pass 4 |
| | Amount pass 5 |
| | Amount pass 6 |
| | Amount |
| | Cost |
| Return | Amount |
| Operation | Status level |
| | Failure amount |
| Supply | Amount [1] |
| | Unsatisfied minimum [1] |

[1] Located on each DC supply in-connector, right click on the connector rather than the component to see it.

## 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Demand factors | Not used | Optional |
| Demand sequence | Optional | Optional |
| Minimum demand profile [1] | Optional | Optional |

[1] Located on each DC supply in-connector

### Constraints

This Component does not have constraints attached.

### Groups

This Component cannot be included in a group.

### 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 |
| IDemand |
| IFlowPredicted |
| IComponent |
| ISymbol |

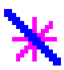
### Resource State

This Component does not have a resource state.

### Status level

This Component reports an end of day status level of *OK* (value = 0) unless supply fails to meet demand and the parameter *Fail.If demand not met* is set to *True*. If the latter is the case, the status level is set to *Failure* (value = 2).

## Discharge



A Discharge allows water to be added to the river system.

The amount of water that is added is defined by a sequence. This sequence can be either a time series or a profile. It is obligatory for at least one of these to be specified.

The daily value can be modified by both:

- A fixed scaling parameter (Flow.Scaling)
- *Climate change factors* specified as a sequence

If the model forecasting option is on, and the Discharge component has to make a prediction, then today's discharge is used as a simple predictor of discharge on future days.

## 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 | 1 | No | No |
| River | Out | 1 | No | No |
| Supply | In | 0 | No | No |
| Supply | Out | 0 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Reach attributes |

| Group | Name |
|---|---|
| | Inlet attributes |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| Flow | Scaling |

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Flow | Net inflow |
| | Natural |

| Group | Name |
|---|---|
| | Net outflow |
| Discharge | Unscaled amount |
| | Scaled amount |
| | Climate change scaling |
| | Total scaling |
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Flow | Required or | Required |
| Climate change | Optional | Optional |

## Constraints

This Component does not have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IFlow |
| IFlowPredicted |
| ISupply |
| IComponent |
| ISymbol |

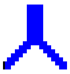
### Resource State

This Component does not have a resource state.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Diversion



A Diversion has a single river reach as input. There are two river type outputs; the main river output and the diverted river output.

The amount diverted to each arm can either be controlled by an operating rule or by what the downstream demands are on each arm. See the *Operating.Mode* parameter.

When the operating rule is being enforced the flow along the diverted river output is controlled by three parameters:

1. *Start threshold*. Flow occurs in the diverted river output only takes place when the input flow is above the value of this parameter.
2. *Transfer rate (%)*. The percentage of the input flow above the *Start Threshold* that is diverted.
3. *Transfer maximum*. The maximum amount that can be diverted.

When the Diversion is in so-called *Demand* mode (see the *Operating.Mode* parameter) the outflow arms are queried to see what the downstream demands are, and the amounts sent to each arm are optimised to satisfy these demands.

In all cases the main river output flow is equal to the river input flow less the diverted flow.

VBA code can be used to program more sophisticated diversion arrangements.

## 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 | 1 | No | No |
| River | Out | 2 | No | No |
| Supply | In | 0 | No | No |
| Supply | Out | 0 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Fill attributes |
| | Outline attributes |
| | Reach attributes |
| | Diversion attributes |
| Arrow | Head |

| Group | Name |
| --- | --- |
| | Angle |
| | Size |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| Operating | Mode |
| Rule | Start threshold |
| | Transfer rate |
| | Transfer maximum |
| | Enforce maximum |
| Rule not obeyed | Report status |
| | Accuracy criterion |
| Demands: main arm | Max d/s flow constraints |
| | Max d/s delay |
| Demands: diversion | Max d/s flow constraints |
| | Max d/s delay |

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Flow | Inflow |
| | Main outflow |
| | Diverted flow |
| Operation | Status level |

## Sequences

There are no sequences for this type of Component.

## Constraints

This Component does not have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IFlow |
| IFlowPredicted |
| ISupply |
| IComponent |
| ISymbol |

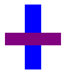
## Resource State

This Component does not have a resource state.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Gauging station



A Gauging Station Component is located on the river network. In the Aquator context it has three purposes:

1. To allow the Aquator modelled flow to be compared with the measured flow at that point in the system.
2. To act as a flow constraint site on the river network.
3. To convert flows to water levels

### Flow constraint

The Gauging station components can be setup to implement a flow constraint in one of three ways:

1. **None**. All available water can be abstracted upstream.
2. **Maintained flow**. Upstream abstraction can take place while the river flow at the Gauging Station is at or above the flow constraint value. Earlier in the day upstream regulators may have added water to the river to meet these maintained flow constraints but at the point of abstraction no account is taken of whether this was done or not. The rule is simply that the downstream flow must not fall below the maintained flow value at any point due to abstraction at the time the abstraction is made. If the river flow is below this value then no water is available.
3. **Prescribed flow**. This is similar to the maintained flow case but relaxed by taking into account whether water has been added by upstream regulators earlier in the day. Abstraction can take place while the river flow at the Gauging Station is at or above the flow constraint value or the natural flow, whichever is less. This implies that water added to the river by an upstream regulator can be abstracted even if the river flow then falls below the flow constraint value, as long as the natural flow is not reduced below what it would have been with no abstraction. Upstream regulators will not add water to meet a prescribed flow value, they (optionally) only add water to meet the expected demand and any maintained flow constraints.

The flow constraint value any day is taken from either a fixed value or a sequence. The parameter *Flow constraint.Use sequence* determines this source.

If set to *True*, the value of flow constraint is taken from a time series if assigned; otherwise from the assigned profile. If neither a time series or a profile are assigned, a flow constraint of zero is used.

If set to *False*, the flow constraint is taken from the parameter *Flow constraint.Value*.

## Water level

A gauging station can optionally convert modelled and/or observed flow to water level. The parameter *Water level.Calculation method* can take one of three values:

1. None
2. Rating table
3. Rating equation

*None* is the default value of this parameter. In this case the output variables *Level.Modelled* and *Level.Observed* contain missing values and no calculation effort is involved.

*Rating table* uses a rating table defined in the parameter *Water Level.Rating table* to convert flow to level. This table may contain any number of rows, each row being one water level/flow co-ordinate of the rating table. The table must be entered in order of increasing flow, with the lowest flow value in the top row. Interpolation between points is linear. No extrapolation is carried out if the flow value to be converted lies outside the first and last rows; in this case the level is returned as missing.

A *Rating equation* may be as simple or complicated as required. The first step is to “Customize” the component by including it the VBA project and calculating the spill in the “CalculateLevel” event. An example is shown below:

```
Private Sub Reservoir_CalculateLevel(ByVal Timestamp As Date, _
                                     ByVal Step As Long, _
                                     ByVal Flow As Single, _
                                     Level As Single)
    Level = 0.056 * (Flow ^ 0.67)
End Sub
```

It is possible to copy and paste the three lines of code above into the VBA code window as a starting point (unwrap the long first line if required).

The second step is to code the inverse of the rating equation (i.e. level derived from flow) as in the example above.

The output variables *Level.Modelled* and *Level.Observed* are derived from variables *Flow.Net* and *Flow.Observed* respectively. Where *Flow.Observed* is simply the values taken from the sequence *Observed flow*.

## 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 | 1 | No | No |
| River | Out | 1 | No | No |
| Supply | In | 0 | No | No |
| Supply | Out | 0 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Failure attributes |
| | Reach attributes |
| Shell | Caption |
| | Path |
| | Arguments |

| Group | Name |
|---|---|
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Forecasting on |
| | Diagnostics on |
| | Trace on |
| | Trace flags |
| Flow constraint | Type |
| | Value |
| | Use sequence |
| | Report failure |
| | Safety margin |
| | Failure margin |
| Percentage take | Above flow constraint |
| Upstream releases | Minimum delay |
| | Maximum delay |
| Water level | Calculation method |
| | Rating table |

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Flow | Net |
| | Natural |
| | Upstream abstractions |
| | Upstream releases |
| | Constraint |
| | Observed |
| Level | Modelled |
| | Observed |
| Operation | Status level |
| | Failure amount |

## 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Prescribed flow | Optional | Optional |
| Observed flow | Optional | Not used |

## Constraints

This Component can have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IFlow |
| IFlowPredicted |
| ISupply |
| IComponent |
| ISymbol |

## Resource State

This Component does not have a resource state.

## Status level

The Gauging station component reports an end of day status level of *OK* (value = 0) unless the parameter *Flow constraint.Type* is set to “Prescribed flow” the downstream flow is less than the flow constraint and the parameter *Flow constraint.Report failure* is set to True. In this case a status level of *Failure* (value = 2) is reported. This condition should not occur under normal operation of the component. It could occur as a result of user modified behaviour with VBA.

# Groundwater

The standard Aquator Groundwater Component is a simple representation of a groundwater source.

No Aquifer modelling is undertaken.

Supply from a Groundwater source is restricted by daily and monthly maximum pumping. Further restrictions can be applied by adding constraints such as daily licence, annual licence and annual yield.

Groundwater sources can be less that 100% efficient so that the some of the water pumped is lost. This is intended for situations where groundwater is pumped into a watercourse to augment river flows.

## 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 | 0 | No | No |
| Supply | In | 0 | No | No |
| Supply | Out | 1 | Yes | Yes (1 min) |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| 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 |

| Group | Name |
| --- | --- |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Options | Animate on |
| | Enabled |
| | Events on |
| | Diagnostics on |
| | Trace on |
| | Trace flags |
| Control flow | Type |
| | Value |
| Pumping | Efficiency |
| | Enforce max limit |
| | Daily max |
| | Month 1 (Jan) max |
| | Month 2 (Feb) max |
| | Month 3 (Mar) max |
| | Month 4 (Apr) max |
| | Month 5 (May) max |
| | Month 6 (Jun) max |
| | Month 7 (Jul) max |
| | Month 8 (Aug) max |
| | Month 9 (Sep) max |
| | Month 10 (Oct) max |
| | Month 11 (Nov) max |

| Group | Name |
|---|---|
| | Month 12 (Dec) max |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |
| Leakage flows | Enforce limit |
| | Reservation limit |
| Minimum flows | Enforce limit |
| | Reservation limit |
| Demand minima | Enforce limit |
| | Reservation limit |
| | Scaling factor |

## 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. States are described at the end of this Chapter.

| Group | Name |
|---|---|
| Yesterdays | Supply |
| | Supply per AO |
| | Supply per RO |

## 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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Supply | Amount |
| | Cost |
| Pumping | Amount |
| | Loss |
| Operation | Control flow |
| | Resource state |
| | 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Control flow | Optional | Optional |
| Cost per Ml | Optional | Optional |

## Constraints

This Component can have constraints attached.

## Groups

This Component can be included in an Abstraction group.

## 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 |
| IComponent |
| ISupply |
| ISchematicObject |

## Resource State

A Groundwater component determines its resource state from the control flow. If the *Control flow.Type* specifies the sequence is to be used then the value is taken from the time series, if specified, otherwise from the profile. If the value is missing then the control flow is set to zero.

Otherwise the *Control flow.Value* parameter is used if the Control flow.Type specifies the parameter is to be used, else the control flow is zero.

If the control flow is zero then the resource state is invalid. Effectively this means an infinite resource state and implies that all available water can be used on pass 4 (excess pass).

Otherwise the resource state equals the amount available divided by the control flow value. Effectively the Groundwater can be "drawn down" on pass 4 until an amount equal to the control flow is left. This amount can be used on pass 5 if necessary.

The state of constraints attached to the groundwater Component also determine its resource state. The value of resource state used in calculations and reported in the variable is the minimum of all the resource states of the component and its constraints.

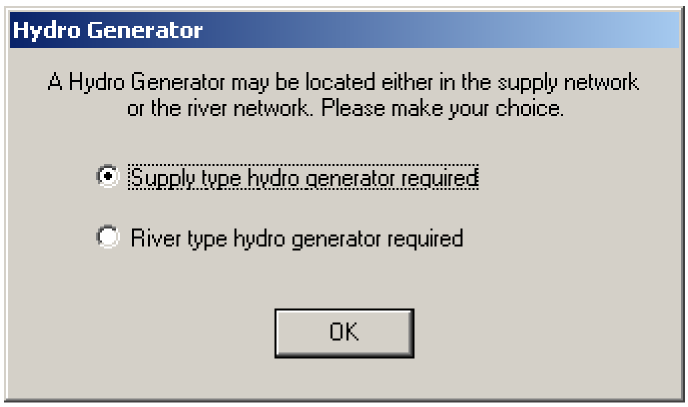
### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Hydro-generator

As water passes through a hydro-generator Component, electricity and hence income are generated.

A hydro generator can be placed either in the supply or river systems. The choice of type of hydro-generator is made when the object is dropped on the schematic. The following dialog box is displayed:




A hydro-generator in the supply system can reduce costs and hence more likely to be used for supply. Water effectively has a negative cost in this Component if the quantity flowing through the generator in any day multiplied by the *Income per Ml* is greater than the *Fixed cost* of operation.

A hydro-generator in the river system can also generate income and the results can be reported, but as it is not part of the supply system, it will not affect the supply/demand allocation.

The maximum amount of water that can pass through a *supply system* hydro-generator is controlled by daily maximum and monthly maximum parameters.

The amount of water flowing through a *river system* hydro-generator is equal to the river flow on that day. If the hydro-generator is connected to the *hydropower* outflow of a Reservoir, flow through the hydro-generator is controlled by the state of the Reservoir, the *Hydro drawdown* control curve and the Reservoir's *Release.Hydropower* parameter which specifies the maximum hydro-power release.

## 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 | 1 R | No | No |
| River | Out | 1 R | No | No |
| Supply | In | 1 S | No | No |
| Supply | Out | 1 S | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

R = River type hydro-generator only

S = Supply type hydro-generator only

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |

| Group | Name |
|---|---|
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Line attributes (cross) |
| | Line attributes (border) |
| | Fill attributes |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| Income | Fixed cost |
| | Income per Ml |
| | Weighting |

| Group | Name |
| --- | --- |
| Generation | Energy per Ml |
| Limits (S) | Enforce min flow |
| | Min flow |
| | Enforce max flow |
| | Max flow |
| | Month 1 (Jan) max |
| | Month 2 (Feb) max |
| | Month 3 (Mar) max |
| | Month 4 (Apr) max |
| | Month 5 (May) max |
| | Month 6 (Jun) max |
| | Month 7 (Jul) max |
| | Month 8 (Aug) max |
| | Month 9 (Sep) max |
| | Month 10 (Oct) max |
| | Month 11 (Nov) max |
| | Month 12 (Dec) max |
| Warning (S) | Min flow |

(S) = Supply type hydro-generator only

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Flow | Amount |
| Generator | Income |
| | Energy |
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Income per Ml | Not used | Optional |

## Constraints

This Component cannot have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IComponent |
| ISupply S |
| IFlow R |
| IFlowPredicted R |
| ISymbol |

S = Only effective for a supply type hydro-generator

R = Only effective for a river type hydro-generator

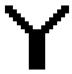
## Resource State

This Component does not have a resource state of its own.

## Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

# Join



A Join enables two branches of the supply network to be connected together. A Join has two supply type in-connectors and one supply type out-connector so, in effect, combines two sources of supply.

If a supply is to *split* rather than *join*, the *Split* Component should be used. If more than three connections are to be made at a single location, consider using the *Service Reservoir* Component.

## 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 | 0 | No | No |
| Supply | In | 2 | No | No |
| Supply | Out | 1 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |

| Group | Name |
|---|---|
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Fill attributes |
| | Outline attributes |
| | Line attributes |
| Arrow | Head |
| | Angle |
| | Size |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Supply | Inflow1 |
| | Inflow2 |
| | Outflow |
| | Cost |
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
| --- | --- | --- |
| Cost per Ml | Optional | Optional |

## Constraints

This Component does not have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IComponent |
| ISupply |
| ISymbol |

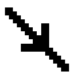
## Resource State

This Component does not have a resource state of its own.

## Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

# Link



A link connects joins together supply type components. It represents pipelines, aqueducts and channels used in the supply distribution network.

Links can have cost associated with their use, support minimum and maximum flow rates and have leakage parameters.

A *minimum flow* is met only if other factors permit, such as *maximum flow* limits elsewhere in the system.

Leakage is effectively a fixed quantity and is defined as the *length of the link* multiplied by a *Leakage loss rate*. Leakage can optionally take place at *zero flow* to simulate a control valve at the downstream end of the link.

## 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 | 0 | No | No |
| Supply | In | 1 | No | No |
| Supply | Out | 1 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Line attributes |
| Arrow | Head |
| | Angle |
| | Size |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |

| Group | Name |
|---|---|
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |
| Limits | Enforce max flow |
| | Max flow |
| | Enforce min flow |
| | Min flow |
| Leakage | Link length |
| | Loss rate |
| | Leak at zero flow |
| Warning | Min flow |

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Supply | Inflow |
| | Outflow |
| | Cost |
| Leakage | Amount |
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Cost per Ml | Optional | Optional |

## Constraints

This Component cannot have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IComponent |
| ISupply |
| IFlow |

| Name |
| --- |
| IFlowPredicted |
| ISymbol |

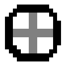
### Resource State

This Component does not have a resource state of its own.

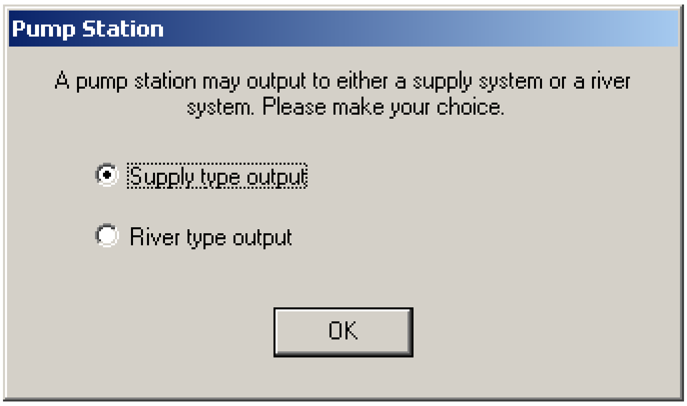
### Status level

If the minimum flow is not met and the parameter *Warning.Min flow* is set to true, this Component type always report an end of day status level of *Warning* (value = 1). Otherwise the end of day status level is set to *OK* (value = 0)

## Pump Station



A pump station pumps water from the supply system to supply or into a river network. The choice of type of pump station is made when the object is dropped on the schematic. The following dialog box is displayed:




A pump station which has a supply type out-connector is controlled by a set of parameters which set the desired minimum pumping rate as well as the daily and month pumping maxima.

In the supply network a pump station simply pumps the water that is moved from supply to demand while enforcing its minimum and maximum flows and adding its pumping costs to the cost of supply.

A pump station which has a river type out-connector demands water from a supply or supplies via its in-connector and pushes the resulting flow into a river. There are three combinations of when this water is moved and how this demand is determined and the choice is governed by the *Pumping.Amount* enumerated parameter which can take one of the following cryptic values.

**Demand (RO)** The demand is determined by either the time series or the profile of the *Demand Sequence*, if specified, otherwise the lower of the daily and monthly maximum pumping parameters.

This demand is moved in **Regulation Order (RO)**, that is to say, early in the day when river regulation takes place. The Pump Station will appear in the *Regulation and Demand Order* box on the *Parameters* tab of the *Model Setup Dialog* where its order with respect to other regulators may be set.

**Demand (AO)** The demand is determined by either the time series or the profile of the *Demand Sequence*, if specified, otherwise the lower of the daily and monthly maximum pumping parameters.

This demand is moved in **Advance Order (AO)**, that is to say, later in the day when demands are being satisfied. The Pump Station will appear in the *Advance and Demand Order* box on the *Parameters* tab of the *Model Setup Dialog* where its order with respect to other demands may be set.

**Release (RO)** The demand is determined by the Pump Station inquiring downriver how much water to add to meet (a) any maintained flow constraints, and (b) any demands on Abstraction components. If the model forecasting option is on then the amount to release can include forecast requirements for future days in the model run.

This demand is moved in **Regulation Order (RO)**, that is to say, early in the day when river regulation takes place. The Pump Station will appear in the *Regulation and Demand Order* box on the *Parameters* tab of the *Model Setup Dialog* where its order with respect to other regulators may be set.

For this mode of operation only additional parameters in the *Release* group fine-tune the behaviour. The release can be scaled to account for losses, and the excess can be designated natural flow or not. And the maximum distance downstream which the pump station will inquire how much to release can be limited.

This is important for speed of simulation since inquiring further downstream than necessary will slow model execution. You can specify the maximum delay downstream if forecasting is on. And you can limit the number of downstream components to query.

## 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 R | No | No |
| Supply | In | 1 | No | No |
| Supply | Out | 1 S | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

R = River type pump station only

S = Supply type pump station only

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Line attributes (cross) |
| | Line attributes (border) |
| | Fill attributes |

| Group | Name |
|---|---|
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Diagnostics on |
| | Trace on |
| | Trace flags |
| Component | Advance order (R) |
| | Regulation order (R) |
| | Demand order (R) |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |
| Limits | Enforce min flow |
| | Enforce max flow |
| | Min flow (S) |
| | Max flow |
| | Month 1 (Jan) max |
| | Month 2 (Feb) max |
| | Month 3 (Mar) max |

| Group | Name |
|---|---|
| | Month 4 (Apr) max |
| | Month 5 (May) max |
| | Month 6 (Jun) max |
| | Month 7 (Jul) max |
| | Month 8 (Aug) max |
| | Month 9 (Sep) max |
| | Month 10 (Oct) max |
| | Month 11 (Nov) max |
| | Month 12 (Dec) max |
| Warning | Min flow (S) |
| Pumping | Amount (R) |
| Sequence | Scale factor (R) |
| Release | Scale factor (R) |
| | Excess is natural flow (R) |
| | Maximum components (R) |
| | Maximum delay (R) |

R = River type pump station only

S = Supply type pump station only

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Demand | Amount (R) |
| Supply | Amount pass 1 |
| | Amount pass 2 |
| | Amount pass 3 |
| | Amount pass 4 |
| | Amount pass 5 |
| | Amount pass 6 |
| | Amount |
| | Cost |

| Group | Name |
| --- | --- |
| Operation | Status level |

R = River type pump station only

## 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
| --- | --- | --- |
| Demand sequence R | Optional | Optional |
| Cost per Ml | Optional | Optional |

R = River type pump station only

## Constraints

This Component cannot have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IComponent |
| ISupply |
| IFlowPredicted R |
| IDemand R |
| ISymbol |

R = Only effective for a river type pump station

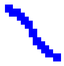
## Resource State

This Component does not have a resource state of its own.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Reach



A Reach Component connects a river type out-connector of an upstream Component to the river type in-connector of a downstream Component. This is a simple representation of a river Reach with no hydrological or hydraulic routing. Outflow is equal to the inflow ***n*** previously, where ***n*** is the travel time in days.

If travel times for all reaches between an Abstraction point and a prescribed flow site (for example, a Gauging Station) are set to zero, Aquator is able to maintain the flow constraint value. If one or more travel times are non- zero, Aquator's forecasting methodology can be used to help prevent flow constraints being broken if the model forecasting option is on.

Reaches with a travel delay can be identified on the schematic when the property *Arrow.Head* is set to True. In this case the number of bars crossing the reach after the arrow show the number of days delay.

Water may be added to a reach by assigning a time series or profile to the *Discharge* sequence. Water may be removed from the reach by setting loss parameters and/or by assigning a time series or profile to the *Abstraction* or *Loss* sequences.

### 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 | 1 | No | No |
| River | Out | 1 | No | No |
| Supply | In | 0 | No | No |
| Supply | Out | 0 | No | No |
| Supply (Demand | In | 0 | No | No |

| Type | In/Out | Default number | Add | Remove |
|---|---|---|---|---|
| Centre) | | | | |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

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

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| Reach | Length |
| | Fixed loss per km |
| | Percent inflow loss |
| Scaling factor | Abstraction sequence |
| | Discharge sequence |

## 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. States are described at the end of this Chapter.

| Group | Name |
|---|---|
| Flows | Travel time |
| | Inflows |

## 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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Inflow | Net |
| | Natural |
| Outflow | Net |
| | Natural |
| Reach | Discharge |
| | Abstraction |
| | Loss |

| Group | Name |
|---|---|
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Discharge | Optional | Optional |
| Abstraction | Optional | Optional |
| Loss | Optional | Optional |

## Constraints

This Component cannot have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IComponent |
| IFlow |
| IFlowPredicted |
| ISupply |
| ISymbol |

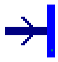
## Resource State

This Component does not have a resource state.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Regulator



A regulator connects a supply network to a river network for the purposes of supporting downstream river abstractions and/or river flows.

A regulator can operate when there is zero time delay between itself and the downstream abstraction or gauging station. It can also operate when there is a time delay providing forecasting is turned on for the model, the regulator and the downstream abstractions and/or gauging stations.

There can be multiple regulators supporting multiple abstractions and gauging stations on a river system.

Releases requested by downstream components can be increased (or decreased) by a scale factor to allow for inefficiencies in the release.

The order in which regulators add water to rivers is controlled by the parameters *Component.Regulation order* and *Component.Demand order*. These parameters may be reviewed and changed in the *Regulation and Demand Order* box on the *Parameters* tab of the *Model Setup* dialog.

### 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 | 1 | No | No |
| River | Out | 1 | No | No |
| Supply | In | 1 | No | No |
| Supply | Out | 0 | No | No |
| Supply (Demand | In | 0 | No | No |

| Type | In/Out | Default number | Add | Remove |
|---|---|---|---|---|
| Centre) | | | | |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

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

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Forecasting on |
| | Forecasting on |
| | Trace on |
| | Trace flags |
| Component | Regulation order |
| | Demand order |
| Demand | Route to supplies |
| | Scale factor |
| | Scaled excess |
| | Excess flow is natural |
| Release | Support river |
| | Scale factor |
| | Scaled excess |
| | Excess flow is natural |
| | Maximum components |
| | Maximum delay |
| Predicted release | Minimum delay |
| | Maximum delay |
| | Method |
| | Amount |
| | Scale factor |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |

## 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. States are described at the end of this Chapter.

| Group | Name |
|---|---|
| Actual release | Previous day |
| Requested release | Previous day |

## 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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Flow | Upstream |
| | Downstream |
| Supply | Amount pass 1 |
| | Amount pass 2 |
| | Amount pass 3 |
| | Amount pass 4 |
| | Amount pass 5 |
| | Amount pass 6 |
| | Amount |
| | Cost |
| Release | Requested amount |
| | Actual amount |
| Demand | Requested amount |
| | Actual amount |
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Cost per Ml | Not used | Optional |
| Predicted release | Not used | Optional |

## Constraints

This Component cannot have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| ISupply |
| IFlow |
| IFlowPredicted |
| IDemand |
| IComponent |
| ISymbol |

## Resource State

This Component does not have a resource state of its own.

## Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

# Reservoir

A Reservoir Component provides storage for water either in the river network or in the supply system. A river Reservoir can be offline, filled from another source such as a river Abstraction or transfer from another Reservoir.

An Aquator Service Reservoir Component differs from an Aquator Reservoir Component in the following ways:

| Behaviour | Reservoir | Service Reservoir |
|---|---|---|
| Storage significant for a daily time step | Yes | No |
| Can allow for evaporation and rainfall | Yes | No |
| Locatable on river network | Yes | No |
| Locatable on supply network | Yes | Yes |
| Control curve | Yes | No |
| Simple to set up | Depends on detail required | Yes |
| Executes quickly during a model run | No | Yes |
| Optionally animates in a model run | Yes | No |

When a Reservoir is first dropped onto the schematic it is shown with a single *river type* out-connector. This connector, labelled *S*, is the Reservoir's spillway connector. All Reservoirs must have a spillway connector to allow for disposal of excess water. This is true also for Reservoirs used that are offline or located in the supply system, because they could have a large rainfall input in excess of any demand thereby resulting in a spill. At the very least this *spill* out-connector must be connected to one river reach and a river termination Component.

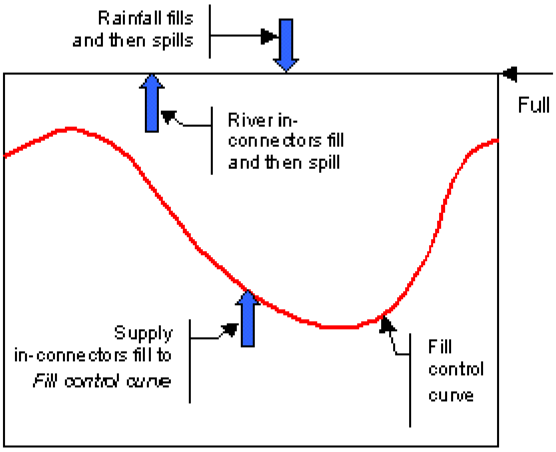
### *Filling the Reservoir*

If the Reservoir is to be located in the river network, right click on the Component in the schematic window and select *Add river inflow*. A river reach may then be added to this in-connector. Multiple river type in-connectors are supported.

If the Reservoir is to be located in the river system but *offline*, such as by river Abstraction or transfer from another Reservoir, right click on the Component in the schematic window and select *Add input*. A supply type *link* Component may then be added to this in-connector. Multiple supply type in-connectors are supported.

The above two methods of filling the Reservoir are not exclusive. It is therefore possible to fill a Reservoir in a complex way.

Provided the sequence *Rainfall* is defined, a Reservoir is also filled by rain falling on the surface. Provided the reservoir starts the day at or below the top water level (i.e. it is not spilling), the surface area for calculating the rainfall input is taken as the mean of the "reservoir full" surface area (i.e. at top water level) of the reservoir and its current surface area. This increase in surface area is an approximation that allows for the collecting effect of the exposed sides of the reservoir during rainfall. If the reservoir is over full on the start of the day, the surface area for rainfall input is simply the same as the current surface area and so no adjustment is made. Rainfall is added at the start of the day.



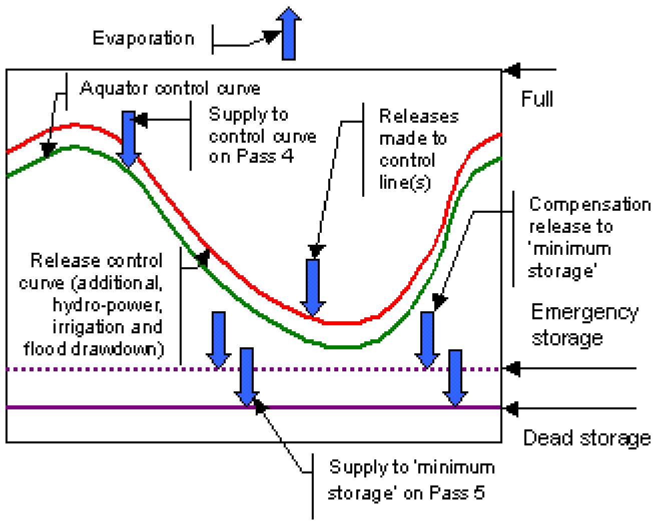

Initial river flows are routed down the river network at the start of the day. If these enter a Reservoir, the reservoir storage is increased by this volume (along with any rainfall), before filling via any *supply* connectors begins. Flow is moved along a supply system to the Reservoir, by the Reservoir acting as a Demand Centre. The *demand* on any day is the amount of water needed to fill the Reservoir to its filling control curve defined by the sequence Control curve – fill. If there is no control curve defined, supplies will attempt to fill the reservoir completely. In practice this may be limited by link and other capacities as well as source availability. Reservoirs have a greater *Advance order* than Demand Centres, which means a Reservoir has a lower priority when it comes to filling by a supply type connection.

### *Drawing the Reservoir Down*

If the sequence *Evaporation* is defined, a Reservoir is drawn down by evaporation from the surface. The current surface area on any one day is used in this calculation. Evaporation is subtracted at the start of the day.

If the reservoir has been configured to allow seepage, this is taken next during the day (see *Seepage* below).

Water is not abstracted or released from the Reservoir for any other purpose other than evaporation, if the storage is below the Reservoir's minimum storage. If the parameter *Use emergency storage* is set to *True*, the minimum storage is taken as the value of parameter *Dead water*; if set to *False*, the minimum storage is taken as the value of parameter *Emergency*. Typically emergency storage should be set at a volume greater than dead storage volume. The difference between the two volumes is used to identify a volume of water to be held in reserve.




If animation is turned on, the minimum storage is shown on the reservoir each day (property *Draw.Min storage line*).

A Reservoir can release a compensation flow to the river network. This flow will normally be routed out of the standard spillway connector. However, the compensation flow can routed differently, if required, by right clicking on the Component on the schematic and then selecting *Add compensation outflow*. Compensation flow will then be routed via this river type out-connector. The amount of compensation flow on any day is taken from one of three sources, in the order listed:

1. The time series assigned to the sequence *Compensation flow*
2. If (1.) above is not defined, the profile assigned to the sequence *Compensation flow*
3. If (1.) and (2.) above are not defined, the value of the parameter *Compensation*

Releases may be made for other purposes; additional, hydro-power, irrigation and flood drawdown. These releases take place in that order but after any compensation release is made. Each release is routed through the Reservoir spillway connector unless the appropriate river out-connector has been added by right clicking on the Component. The amount of the *additional* release on any day is taken from one of three sources, in the order listed:

1. The time series assigned to the sequence *Additional outflow*
2. If (1.) above is not defined, the profile assigned to the sequence *Additional outflow*'.
3. If (1.) and (2.) above are not defined, the value of the parameter *Additional outflow*.

The quantities of the hydro-power, irrigation and flood drawdown releases are taken from the values of parameters *Hydro-power*, *Irrigation* and *Flood drawdown*. These releases only take place above the level of storage defined by the *Hydro drawdown*, *Irrigation drawdown* and *Flood drawdown* control curve sequences.

If the Reservoir is above its maximum storage at the end of the day, it spills the excess volume. This flow is routed via the spillway out-connector.

### Seepage

The following options for seepage loss from the reservoir are supported by this component:

1. No seepage loss
2. Constant value
3. Percent of current storage
4. Level related amount
5. Sequence of values (as time series or repeating annual profile) in mm. This is multiplier by today's area to give the seepage volume.
6. Sequence of values in Ml/d to provide the daily seepage amount.

The parameter *Seepage.Method* determines which method is to be used.

If *Seepage.Method* is set to "Constant", the seepage amount each day is taken from the *Seepage.Constant amount* parameter. Today's seepage volume is value of this parameter (mm) multiplied by the current surface area of the reservoir.

If *Seepage.Method* is set to "Percent storage", today's seepage is calculated from the parameter *Seepage.Percent storage* multiplied by the storage at the start of the day (after the effects of rainfall and evaporation have been taken into account).

If *Seepage.Method* is set to “Level related”, seepage is interpolated from the *Level.Relationships* table using today’s water level (after the effects of rainfall and evaporation have been taken into account).

If *Seepage.Method* is set to “Seepage sequence”, seepage is taken from the time series assigned to the *Seepage* sequence. If no time series is assigned, the profile value is used. These values are in mm and multiplied by today’s surface area to provide the seepage volume today.

If *Seepage.Method* is set to “Ml/d sequence”, seepage is taken from the time series assigned to the *Seepage (Ml/d)* sequence. If no time series is assigned, the profile value is used. These values are in Ml/d. If a constant value of seepage is required throughout the model run, the simplest solution is to define a monthly “Flow” profile in Ml/d with all 12 values set to the seepage amount and then set up the reservoir to use this profile on this option.

Seepage water is taken from the reservoir at the start of the day just after the effects of rainfall and evaporation have been allowed for. Depending on the value of the *Seepage.Destination* seepage water can either be lost from the system when set to “System loss” or kept in the system by selecting a river outflow connector for its destination. The only reservoir variable that includes seepage is *Seepage.Amount*, whether or not the water is kept in the system or lost.

### *Spill*

Reservoirs can be configured to either spill all water above the top water level (TWL) each day or to spill a controlled amount. The key parameter in defining the spill behaviour is the *Level.Relationships* table. This table specifies the storage, surface area, spill amount and seepage over the full range of water levels experienced at the reservoir.

The reservoir is considered to be “Full” when the water level is at TWL and to be “Spilling” when above TWL. Water levels are relative to any desired datum and TWL is not necessarily zero. This is a change from V3 onwards.

If the *Level.Relationships* table does not have any entries with non-zero spill amounts defined then TWL is defined by the level in the topmost row of the table, the spill regime is not defined, and all water above TWL is spilt at the end of the day. For example:

| Level (m) | Area (sq km) | Storage (Ml) | Spill (Ml/d) | Seepage (Ml/d) |
|---|---|---|---|---|
| 10 | 1 | 100000 | 0 | 0 |
| -15 | 0.8 | 70000 | 0 | 0 |
| -40 | 0.4 | 50000 | 0 | 0 |
| -90 | 0.01 | 0 | 0 | 0 |

Here the TWL is defined as being a level of 10 m.

Alternatively, if one or more of the topmost rows define non-zero spill amounts, then TWL is defined by the maximum level in any row with zero spill (i.e. the highest row in the table with zero spill) and spill is controlled by the non-zero spill amounts above TWL.

If a controlled amount is to spilt it is necessary to extend this table above TWL with positive level values, giving the spill amount at each level. Aquator interpolates for the value of spill between points. An example of the *Level.Relationships* table in the case is as follows:

| Level (m) | Area (sq km) | Storage (Ml) | Spill (Ml/d) | Seepage (Ml/d) |
|---|---|---|---|---|
| 18 | 2 | 120000 | 1020.6 | 0 |
| 16 | 1.7 | 115000 | 423.5 | 0 |
| 13 | 1.4 | 110000 | 85.5 | 0 |
| 10 | 1 | 100000 | 0 | 0 |
| -15 | 0.8 | 70000 | 0 | 0 |
| -40 | 0.4 | 50000 | 0 | 0 |
| -90 | 0.01 | 0 | 0 | 0 |

Here the TWL is again 10 m i.e. the maximum level with zero spill.

If, after any spill defined by the above table has taken place at the end of the day, the water level is above the topmost level (i.e. above +18m in the example above), Aquator forces an additional spill to this upper level. This ensures the next day starts with the water level in the bounds of the data defined in the table. It is good idea to make sure that the levels in the table extend high enough to cover the maximum possible water level to avoid this situation.

If spill is to be calculated from a formula rather than interpolated from a table this can be achieved by first simply defining the spill range as above, extending to the maximum possible water level for the reasons given. Make sure the quantity entered for spill at TWL is zero, and provide arbitrary, but greater than zero values of spill at water levels above TWL. The arbitrary values will be replaced by values from your equation.

The next step is to “Customize” the component by including it in the VBA project and calculating the spill in the “CalculateSpill” event. An example is shown below:

```
Private Sub Reservoir_CalculateSpill(ByVal Timestamp As Date, _
                                     ByVal Step As Long, _
                                     ByVal WaterLevel As Single, _
                                     SpillAmount As Single)
```

```
    SpillAmount = 64.213 * (WaterLevel ^ 1.5)
End Sub
```

It is possible to copy and paste the three lines of code above into the VBA code window as a starting point (unwrap the long first line if required).

You will find your VBA code is called once at the start of the run and then on days the reservoir ends up above TWL and spill needs to be calculated. The purpose of the first call in the model run is to test for the presence of VBA code. Simply return the "SpillAmount" calculated by your equation for the "WaterLevel" provided. Failure to do this will result in your custom code being ignored throughout the run.

### *Demand Saving*

If the parameter *Demand saving* is set to *True*, the state of a Reservoir can be used to trigger system wide demand saving measures. If demand saving has been triggered, all Demand Centre demands are reduced by the same demand saving factor. Demand saving levels may be used to represent the effects of a water saving publicity campaign, hose pipe ban and other water saving or restriction measures.

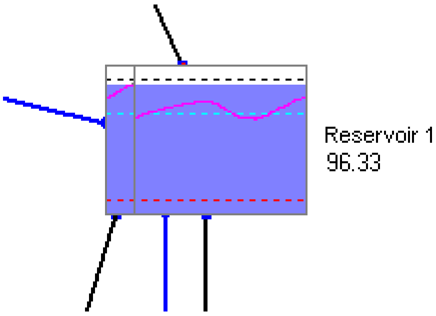
Successive demand saving levels indicate droughts of increasing severity. The control curve sequences *Level n control curve* define the Reservoir storage on a day by day basis of the threshold storage for each of the demand saving levels. A Level 1 storage should be higher than a Level 2 storage. Therefore if the Reservoir storage was less than the *Level 1 control curve* and greater than the *Level 1 control curve*, this Component would report a demand saving level of 1. The highest reported demand saving level is used by Aquator to set the system wide demand saving level.

### *Aquator Control Curve*

The sequence *Control curve* is used by this Component to determine its *Resource State* (see The Chapter on **Aquator**, section: *How it all works* ). If the current Reservoir is above this *control curve*, the Reservoir is deemed to have *excess* water and will release water in Pass 4 of the daily allocation process as a result. If the reservoir is below its control curve, no water is available to meet demand on Pass 4. If animation is turned on, the control curve is shown on the reservoir each day (property *Draw.Control curve line*).

### *Schematic animation*

The reservoir component is able to animate its behaviour during a model run as illustrated by the example below:




The height of the solid blue area represents the current state of the storage.

The dashed red line shows the lowest storage that the reservoir can be drawn down to. This could be either the dead storage or the emergency storage if the option is set to not use emergency storage.

The cyan dashed line shows the Aquator control curve storage for the current day.

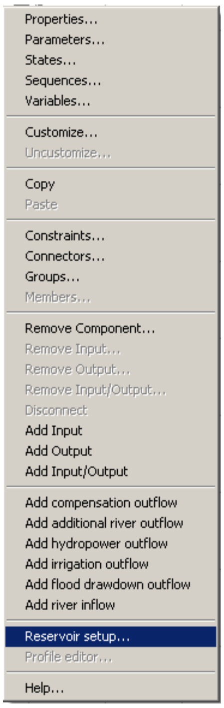
The black dashed line shows the TWL. If the solid blue area extends above this line, the reservoir is spilling.

The top of the reservoir rectangle is defined by the highest point in the *Level.Relationships* table.

If the parameter *Options.Animate history* is set to "True" the last year of calculated reservoir storage is drawn on the component as illustrated above with the magenta line. The left hand side of the component on the schematic represents the last 1st of January; the right hand side represents December 31st. The vertical grey bar represents the current day. In the example above the model has been paused in February. Tip: the standard size of the reservoir component can make the historic storage line difficult to interpret; if this is the case simply enlarge the reservoir on the schematic or keep the size the same and zoom in on that part of the schematic.

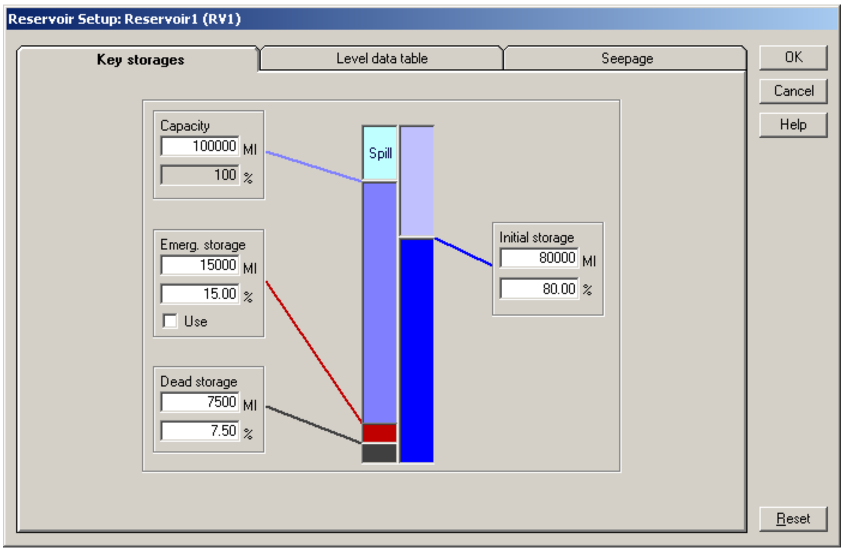
## Reservoir setup form

Some aspects of setting up a reservoir are made easier by means of the Reservoir setup form described here. Right clicking on the reservoir component on the schematic to reveals the context menu shown below. Selecting the highlighted item invokes the reservoir setup form:




## *Key storages*

The first tab of the form, “Key storages”, allows characteristic storages to be defined:




*Capacity* is the volume stored when the reservoir is just full (i.e. the water surface is at top water level (TWL) – any higher and the reservoir will spill). The capacity in mega litres can be changed, but the percentage full cannot because this is always 100% by definition. If full storage is changed, the other characteristic storages or percent storages shown on the form are adjusted accordingly. Also the storage at TWL in Level data table (the second tab on the form) is changed to match the new definition.

If the reservoir is configured above spillway level (TWL) this region is shown coloured cyan on form graphic above. In this "Spill" state a level related lookup table of determines the amount of spill each day. A spillway rating formula may replace the lookup table, see *Level data table*.

*Emergency storage* is that volume of water that is reserved for emergency use. Emergency storage can optionally be used depending on whether or not the "Use" check box is ticked. If checked the reservoir will make releases and provide supply when in this state. If not checked, the emergency storage is not used, although it can be depleted by evaporation.

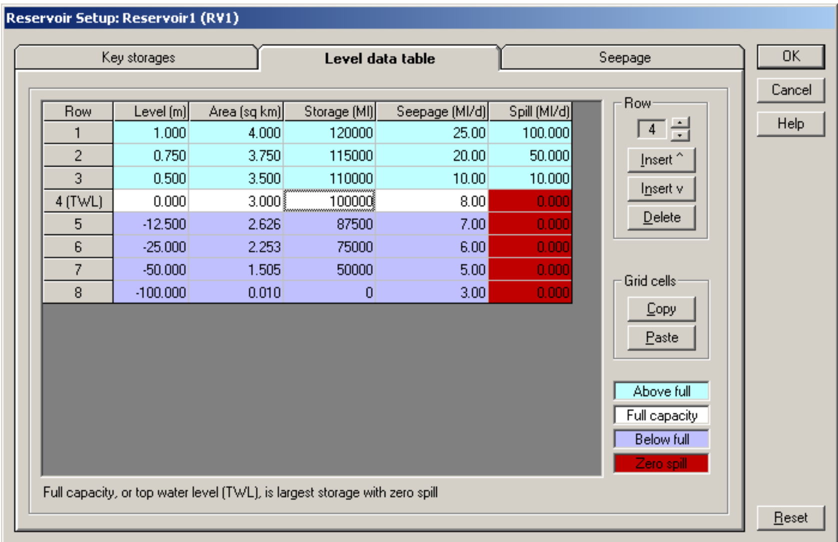
*Dead storage* is the volume of water in the bottom of the reservoir that cannot physically be abstracted or released. It can however be depleted by evaporation.

*Emergency storage* must be at or above *Dead storage*

*Initial storage* is a state value rather than a parameter and defines the amount of water in the reservoir at the start of the model run. Initial storage may be greater than 100%, provided this is within the definition of the spill region.

### *Level data table*

The table (array) parameter that defines the level related properties of the reservoir is edited on the second tab of this form:



Water level in metres is specified in the first column of the table. These values *must* decrease with row number.

The topmost row where spill is zero indicates top water leve (TWL). TWL need not be at zero metres. Rows above TWL define the reservoir in the spill state and are optional. If no rows are defined, all water above TWL at the end of the day is spilt. If this region is defined, it should extend high enough to cover the maximum possible spill, otherwise excess water over and above the defined maximum is spilt at the end of the day. In other words start of day storage is never above the top row in this table.

There *must* always be at least one row below TWL to define the characteristics in the non spill, normal, operating region of the reservoir.

Values in the *Area* (in square kilometres) column *must not* increase with row number. Area is used in the calculations if the effects of rainfall and evaporation are being modelled on the reservoir. *Area* can also be used in seepage calculations.

*Storage* in mega litres also *must not* decrease with row number. If the storage at TWL is changed this is automatically reflected in the “Full storage” parameter on the first tab on this form.

The amount of *Spill* in mega litres per day can be defined in rows above TWL. If the amount of spill is to be calculated by formula rather than looked up in this table, this is done using VBA.  First add another row to the table above TWL which defines the top most point for the rating. The value of spill you enter on rows above TWL will not be used, so are not important. Next “Customize” this reservoir component (right mouse click on the reservoir and select “Customize”) and open it’s VBA code window. Now paste the following template code into this window, unwrapping the first line if necessary:

```
Private Sub Reservoir_CalculateSpill(ByVal Timestamp As Date, _
                                     ByVal Step As Long, _
                                     ByVal WaterLevel As Single, _
                                     SpillAmount As Single)
  SpillAmount = 64.213 * (WaterLevel ^ 1.5)
End Sub
```

Finally edit the second line to calculate the spill, adding additional lines if required.

The spillway rating may be as complicated as required – simply return the spill amount in *SpillAmount*. It is important that the spill equation you supply returns zero spill at TWL; if it does not the spill table rather than the equation will be used.

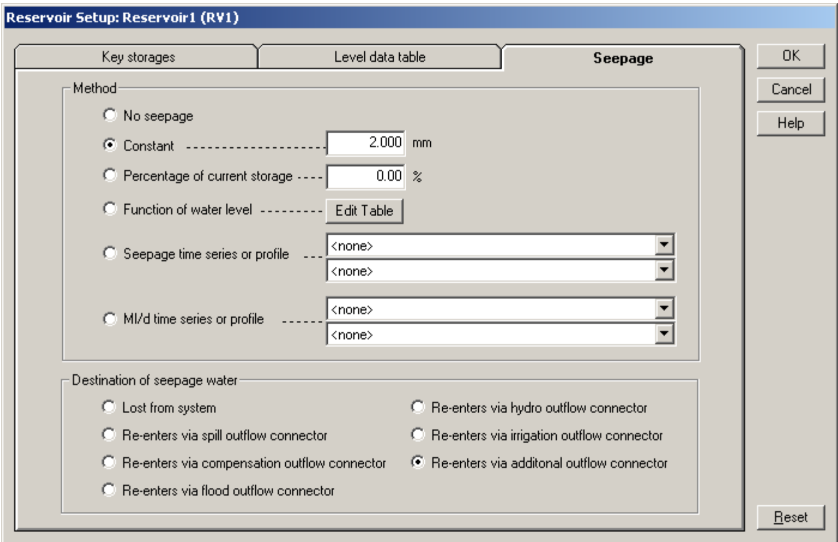
The level related *Seepage* in mega litres per day in the last column is only used if the reservoir parameter *Seepage.Method* is set to “Level related”.

### *Seepage*

Seepage from the reservoir is controlled by the third tab. The Seepage calculation method can be one of the following:

1. No seepage
2. A constant in mm value every day. This is multiplied by the start of day reservoir surface area to give seepage in Ml.
3. A percentage of the reservoir storage at the start of the day
4. A function of the start of day water level in the description above for the previous form tab.
5. A time series or profile of mm seepage. This is similar to method ii above, but the amount varies each day.
6. A time series or profile of Ml/d defining the seepage each day

The choice of method and the controlling parameters and sequences associated with these methods defined on the upper part of this tab:




Note that when seepage is a function of water level this is defined in the Level data table on the second tab.

The lower part of the seepages tab on this form allows seepage water to be either lost from the system or to emerge from one of the river outflow connectors on the reservoir.

If a river outflow connector is chosen, seepage water does not count toward that particular contribution. For example, if seepage is sent to the compensation outflow, it is not included in the compensation release – so the amount released for compensation is the same whatever the seepage. Consequently the output variables that show the amount flowing from each type of river outflow connector do not include seepage. This simulates the situation where seepage water returns somewhere downstream of the reservoir. The only output variable that accounts for seepage is “Seepage.Amount”.

## 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 | Yes | Yes |
| River | Out | 1 | Yes * | Yes * |
| Supply | In | 0 | Yes | Yes |
| Supply | Out | 0 | Yes | Yes |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | Yes | Yes |

* = Spillway cannot be removed

Compensation, additional, hydro, irrigation and flood drawdown can be added and removed

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |

| Group | Name |
|---|---|
| | Name X |
| | Name Y |
| | Angle |
| Draw | Border line |
| | Min storage line |
| | Control curve line |
| | History line |
| | Spillway level |
| | Full attributes |
| | Empty attributes |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Animate history |
| | Enabled |
| | Events on |
| | Diagnostics on |
| | Trace on |
| | Trace flags |
| Component | Advance order |
| | Demand order |

| Group | Name |
|---|---|
| Operation | Demand saving |
| | Use emergency storage |
| | Minimum flows can overfill |
| Release | Compensation |
| | Additional outflow |
| | Hydropower |
| | Irrigation |
| | Flood drawdown |
| | Failure margin |
| Seepage | Method |
| | Constant amount |
| | Percent storage |
| | Destination |
| Level | Relationships |
| Storage | Capacity |
| | Abs. emergency level / Rel. emergency level |
| | Abs. dead water level / Rel. dead water level |
| | Abs. failure margin / Rel. failure margin |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |
| Fail | At dead water level |
| | At emergency storage level |
| | When compensation not met |
| | When additional outflow not met |
| | When hydropower not met |
| | When irrigation not met |
| | At demand saving level |
| Leakage flows | Enforce limit |
| | Reservation limit |
| Minimum flows | Enforce limit |
| | Reservation limit |
| Demand minima | Enforce limit |
| | Reservation limit |

| Group | Name |
|---|---|
| | Scaling factor |
| Is natural flow | Compensation release |
| | Additional release |
| | Hydropower release |
| | Irrigation release |
| | Flood drawdown release |
| | Spill |

## 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. States are described at the end of this Chapter.

| Group | Name |
|---|---|
| Storage | Abs. Start value<br>Rel. Start value |
| Yesterdays | Demand saving level |
| | Supply |
| | Supply per AO |
| | Supply per RO |

## 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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Storage | Calculated |
| | Calculated (%) |
| | Observed |
| | Observed (%) |
| | Control |
| | Control (%) |
| | Hydropower |
| | Hydropower (%) |
| | Irrigation |
| | Irrigation (%) |

| Group | Name |
|---|---|
| | Flood |
| | Flood (%) |
| | Emergency |
| | Emergency (%) |
| | Dead water |
| | Dead water (%) |
| | Adjustment |
| Reservoir | Level |
| | Area |
| Demand saving | Threshold 1 |
| | Threshold 1 (%) |
| | Threshold 2 |
| | Threshold 2 (%) |
| | Threshold 3 |
| | Threshold 3 (%) |
| | Threshold 4 |
| | Threshold 4 (%) |
| | Threshold 5 |
| | Threshold 5 (%) |
| | Level |
| Climate | Rainfall |
| | Evaporation |
| | Rainfall scaling |
| | Evaporation scaling |
| | Rainfall (scaled) |
| | Evaporation (scaled) |
| Flow | Total river inflow |
| | Total releases to rivers |
| Supply | From sources pass 1 |
| | From sources pass 2 |
| | From sources pass 3 |
| | From sources pass 4 |
| | From sources pass 5 |
| | From sources pass 6 |
| | From sources |
| | To demands pass 1 |

| Group | Name |
|---|---|
| | To demands pass 2 |
| | To demands pass 3 |
| | To demands pass 4 |
| | To demands pass 5 |
| | To demands pass 6 |
| | To demands |
| Cost | Supply |
| | Fill |
| Required | Compensation |
| | Additional outflow |
| | Hydropower |
| | Irrigation |
| Release | Compensation |
| | Additional outflow |
| | Hydropower |
| | Irrigation |
| | Flood drawdown |
| | Spill |
| Seepage | Amount |
| Operation | Resource state |
| | Status level |
| | Failure amount |

## 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Rainfall | Optional | Optional |
| Evaporation | Optional | Optional |
| Seepage | Optional | Optional |
| Seepage (Ml/d) | Optional | Optional |
| Control curve | Optional | Optional |

| Name | Time series | Profile |
|---|---|---|
| Control curve - fill | Optional | Optional |
| Hydro drawdown | Not used | Optional |
| Irrigation drawdown | Not used | Optional |
| Flood drawdown | Not used | Optional |
| Compensation flow | Optional | Optional |
| Additional outflow | Optional | Optional |
| Climate change - rainfall | Not used | Optional |
| Climate change - evaporation | Not used | Optional |
| Observed storage | Optional | Not used |
| Level 1 control curve | Not used | Optional |
| Level 2 control curve | Not used | Optional |
| Level 3 control curve | Not used | Optional |
| Level 4 control curve | Not used | Optional |
| Level 5 control curve | Not used | Optional |
| Storage adjustment | Optional | Optional |
| Demand saving start allowed | Optional | Optional |
| Cost per Ml | Not used | Optional |

## Constraints

This Component can have constraints attached.

## Groups

This Component can be included in a group.

## 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 |
| ISupply |
| IFlow |
| IFlowPredicted |

| Name |
| --- |
| IComponent |
| IDemand |
| IResource |
| ISymbol |
| IReservoirData |
| IGroupMember |

## Resource State

If the Reservoir has the control curve sequence defined, the resource state is calculated as:

= (Current storage – minimum storage)

/ (Control curve storage – minimum storage)

If there is no control curve the resource state is invalid effectively infinite) if the current storage is above the minimum storage; otherwise it is set to zero. An invalid resource state implies that all available water may be released on pass 4 (excess pass).

If constraints are attached to the reservoir which report valid resource states, the minimum of the reservoir's resource state and any constraint's resource state is used in calculations and reported in the variable.

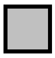
## Status level

This Component type reports an end of day status level of *OK* (value = 0) unless:

- The parameter Fail.At dead water level is set to True and the end of day storage is at or below the dead water level. Or:
- The parameter *Fail.At emergency storage level* is set to *True* and the end of day storage is at or below the emergency storage level. Or:
- The parameter *Fail.When compensation not met* is set to *True* and the compensation flow released is less than the required compensation flow. Or:
- The parameter *Fail.When additional outflow not met* is set to *True* and the additional outflow released is less than the required additional outflow. Or:
- The parameter *Fail.When hydropower not met* is set to *True* and the hydropower release is less than the required hydropower release. Or:

- The parameter *Fail.When irrigation not met* is set to *True* and the irrigation release is less than the required irrigation release. Or:
- The parameter *Fail.At demand saving level* is set to a value other than *None* and the end of day storage is less than demand saving control line specified.

## Service Reservoir



A Service Reservoir is located in the supply system only and has no significant storage in at a daily time step. See *Reservoir* for a more complete differentiation of Reservoir and Service Reservoir.

A Service Reservoir can have multiple inputs and outputs.

### 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 | 0 | No | No |
| Supply | In | 1 | Yes | Yes |
| Supply | Out | 1 | Yes | Yes |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | Yes | Yes |

### Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |

| Group | Name |
|---|---|
| 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 |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| | Suppress warnings |
| Cost | Fixed cost |
| | Cost per Ml |

| Group | Name |
|---|---|
| | Weighting |
| Losses | Fixed loss |
| | Percent loss |

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Supply | Inflow |
| | Outflow |
| | Loss |
| | Cost |
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Cost per Ml | Optional | Optional |

## Constraints

This Component does not have constraints attached.

## Groups

This Component cannot be included in a group.

## 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 |
| IComponent |
| ISupply |
| ISymbol |

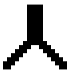
### Resource State

This Component does not have a resource state of its own.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Split



A Split enables the supply network to branch into two directions in a downstream direction. A split has one supply type in-connector and two supply type out-connector so, in effect, divides a source of supply into two.

If a supply is to *join* rather than *split*, the *Join* Component should be used. If more than three connections are to be made at a single location, consider using the *Service Reservoir* Component.

### 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 | 0 | No | No |
| Supply | In | 1 | No | No |

| Type | In/Out | Default number | Add | Remove |
|---|---|---|---|---|
| Supply | Out | 2 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Fill attributes |
| | Outline attributes |
| | Line attributes |
| Arrow | Head |
| | Angle |
| | Size |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |

| Group | Name |
|---|---|
| | Location |
| | Manager |
| | Other |

### Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
|---|---|
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |

### States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Supply | Inflow |
| | Outflow |
| | Loss |
| | Cost |
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Cost per Ml | Optional | Optional |

### Constraints

This Component does not have constraints attached.

### Groups

This Component cannot be included in a group.

### 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 |
| IComponent |
| ISupply |
| ISymbol |

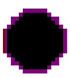
### Resource State

This Component does not have a resource state of its own.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Termination



A Termination is required as the last Component at the downstream end of a river reach. The purpose of the Termination is to account for water leaving the system in the water balance calculations. It also serves to indicate the scope of the model has been considered in full by the designer (i.e. no *loose ends* of river have been left by accident).

### 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 | 1 | Yes | Yes |
| River | Out | 0 | No | No |
| Supply | In | 0 | No | No |
| Supply | Out | 0 | No | No |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

### Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| 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 |

| Group | Name |
| --- | --- |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |

## States

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. Variables are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Flow | Net |
| | Natural |
| Operation | Status level |

### Sequences

There are no sequences for this type of Component.

### Constraints

This Component cannot have constraints attached.

### Groups

This Component cannot be included in a group.

### 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 |
| IComponent |
| IFlow |
| ISymbol |

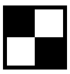
### Resource State

This Component does not have a resource state.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## Water Treatment Works



A Water Treatment Works is located in the supply system and can have multiple supply type inputs and outputs.

If the works has a significant process water requirement, a value, expressed as a percentage of the throughput, should be entered in the *Process water.Percent of demand* parameter and a single river type out-connector added to the works allow this process water to be returned to the river system.

If the works has a significant clear water return, a value, expressed as a percentage of the process water, should be entered in the *Clear water.Percent of process water* parameter and a river type out-connector added to the works allow this process water to be returned to the river system.

This Component also supports *fixed* and *percentage losses* which are not returned to the river system.

## 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 | 0 | Yes * | Yes |
| Supply | In | 1 | Yes | Yes |
| Supply | Out | 1 | Yes | Yes |
| Supply (Demand Centre) | In | 0 | No | No |
| Supply | Bi-Di | 0 | No | No |

* A river type out-connector may be added to allow process water to be returned to the river system and a river type out-connector may be added to allow clear water returns to be added to the river system.

## Properties

A Component only has one set of properties. Properties do not change during a model run. Properties are described at the end of this Chapter.

| Group | Name |
|---|---|
| Component | Display Name |
| | Draw order |
| Options | Show name |
| Schematic | Left |
| | Top |
| | Width |
| | Height |

| Group | Name |
| --- | --- |
| | Name X |
| | Name Y |
| | Angle |
| Draw | Line attributes |
| | Fill attributes 1 |
| | Fill attributes 2 |
| Shell | Caption |
| | Path |
| | Arguments |
| Info | Identifier |
| | Grid reference |
| | GIS reference |
| | Cross reference |
| | Owner |
| | Location |
| | Manager |
| | Other |

## Parameters

A Component can have more than one set of parameters. Parameters do not normally change during a model run. Parameters are described at the end of this Chapter.

| Group | Name |
| --- | --- |
| Options | Animate on |
| | Enabled |
| | Events on |
| | Trace on |
| | Trace flags |
| | Suppress warnings |
| Cost | Fixed cost |
| | Cost per Ml |
| | Weighting |
| Limits | Enforce min flow |
| | Min flow |
| | Enforce max capacity |
| Capacity | Daily max |

| Group | Name |
|---|---|
| | Month 1 (Jan) max |
| | Month 2 (Feb) max |
| | Month 3 (Mar) max |
| | Month 4 (Apr) max |
| | Month 5 (May) max |
| | Month 6 (Jun) max |
| | Month 7 (Jul) max |
| | Month 8 (Aug) max |
| | Month 9 (Sep) max |
| | Month 10 (Oct) max |
| | Month 11 (Nov) max |
| | Month 12 (Dec) max |
| Process water | Percent of demand |
| | Is natural flow |
| Clear water | Percent of process water |
| | Is natural flow |
| Losses | Fixed loss |
| | Percent loss |
| Warning | Min flow |

### States

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. Variables are described at the end of this Chapter.

| Group | Name |
|---|---|
| Supply | Inflow |
| | Outflow |
| | Cost |
| Treatment | Process water |
| | Clear water return |
| | Loss |
| 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). Sequences are described at the end of this Chapter.

| Name | Time series | Profile |
|---|---|---|
| Cost per Ml | Optional | Optional |

### Constraints

This Component does not have constraints attached.

### Groups

This Component cannot be included in a group.

### 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 |
| IComponent |
| ISupply |
| IFlowPredicted |
| ISymbol |

### Resource State

This Component does not have a resource state of its own.

### Status level

This Component type always reports an end of day status level of *OK* (value = 0) unless changed by the VBA programmer.

## 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

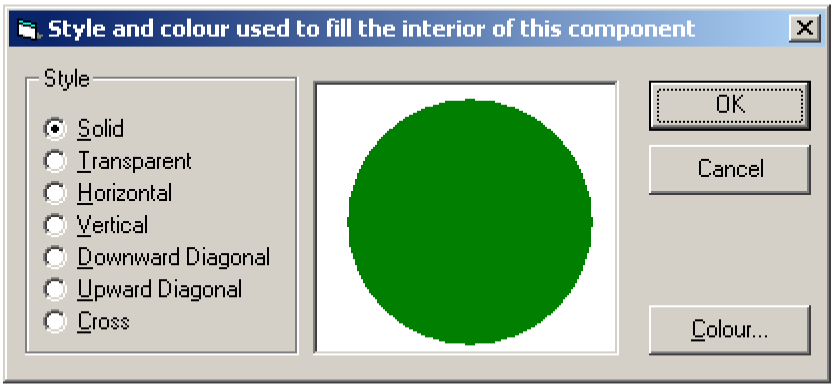
Reserved for future use.

## Draw.Failure attributes

The style to use when the component is animating during a model run and a failure is reported by the component on the current day.

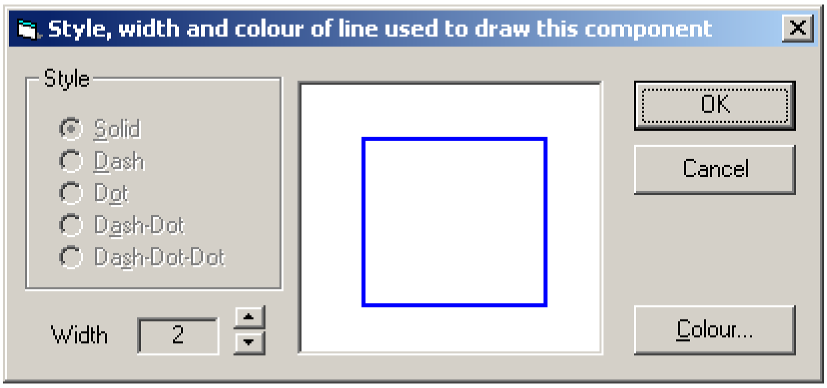
## Draw.[Fill attributes]

*[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.[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.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 form 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

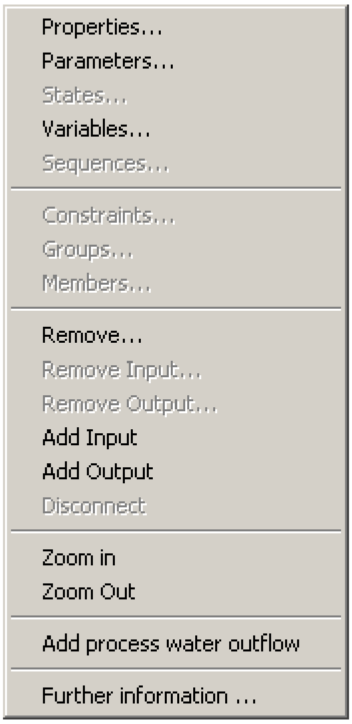
These three properties allow each Aquator Component to be linked to an external application.

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.

### Abstraction.Daily max

The maximum abstraction that can occur on any day. The actual abstraction may be lower than this value if it reduced by either the current monthly maximum abstraction, the requirement of the prescribed flow or a lower demand from the supply system.

### Abstraction.Enforce maximum

When set to False the daily and monthly maximum parameters are ignored. When set to True the daily and monthly maximum parameters are enforced.

### Abstraction.Month n (xxx) max

The maximum abstraction that can occur on any day in the month. The actual abstraction may be lower than this value if it reduced by either the daily maximum abstraction, the requirement of the prescribed flow or a lower demand from the supply system.

### Blend.Fraction

Fraction of the output water that comes from this input. Only used if parameter *Blender.Method* is set to **Fixed ratios**.

### Blender.Failure margin

When checking for a blend failure the determinand limits are increased by this percentage when checking for a failure.

### Blender.Method

There are four blending methods:

1. **Fixed ratios** – Blends using fixed ratios. Does not attempt to keep the determinand levels in the outflow below set limits.
2. **Least cost** – Minimises the cost of water supplied with the constraint that no determinand limit is exceeded.
3. **Best resource state** – Maximises the use of supplies with the best resource state with the constraint that no determinand limit is exceeded.
4. **Optimal** – Minimises the cost of water supplied when excess water is available, otherwise maximize the use of supplies with the best resource state, both subject to the constraint that no determinand limit is exceeded.

## Blender.Report failures

If output determinand level is exceeded this can be reported to Aquator either as a failure or a warning. This parameter allows this choice to be made; **True** for report as failure, **False** for report as a warning.

## Capacity.Daily max

The maximum quantity that can be moved through this Component on any day. The actual amount may be lower than this value if it reduced by either the current monthly maximum value or by limits elsewhere in the supply system.

## Capacity.Month n (xxx) max

The maximum quantity that can be moved through this Component on any day in the month. The actual amount may be lower than this value if it reduced by either the daily maximum capacity or by limits elsewhere in the supply system.

## Check downstream.Maximum flow constraints

This parameter controls how far downstream to look when an abstraction is taking place to ensure flow constraints are not broken. The distance is measured in terms of components that implement flow constraint.

If, for example, downstream of the current abstraction there was another abstraction followed by two gauging stations and it was a condition that the flow constraint on the first gauging station downstream was not broken but not a condition on the second, this parameter should be set to 2. The abstraction downstream counts as the first flow constraint site and the next gauging station counts as the second. If, in this example, the value was set to 3 or more, the second gauging station downstream would prevent its flow constraint being broken.

## Check downstream.Maximum delay

This parameter controls how far downstream to look when an abstraction is taking place to ensure flow constraints are not broken. The distance is measured in terms of reach time delay in days.

## Clear water.Is natural flow

Aquator records river flow in three categories; natural, releases and abstractions. This parameter determines whether any *clear water* returned to the river system should be in the category *natural* or *release*. The category can determine whether or not this water is abstracted downstream.

## Clear water.Percent of process water

The percentage of process water that is clear water and returned separately to the river system.

## Component.Advance order

This is a read only parameter set by the Component itself and Aquator. All components with an advance order of 1 have their demand met first. All the Demand Centres have an advance order of 1. Reservoirs connected directly to Demand Centres are filled next (advance order = 2). Reservoirs which flow through another Reservoir before reaching the Demand Centre are next with an advance order of 3. The user cannot change the advance order.

## Component.Demand order

Demand order is unique within each *advance order* set and determines which Component has priority in taking water on each of the 5 Passes. The user can change the demand order. It is best in general, to let Demand Centres and Reservoirs with the fewest means of supply have the highest priority (i.e. lowest demand order value).

## Component.Regulation order

The order number of this component in making regulation releases. Regulators and Pump Stations with different regulation order (RO) add water to the river independently, at different times, starting with RO=1, followed by RO=2, etc.

## Control flow.Type, Control flow.Value (Abstraction)

The control flow is used to determine the component's resource state, which in turn controls how much excess water (water that can be supplied on pass 4) is available. These two parameters provide alternative methods of assessing the control flow.

*Control flow.Type* can take one of the following values:

- **Last abstraction** – Resource state determined as the ratio of current river flow divided by yesterday's abstraction
- **Parameter value** – Resource state determined as the ratio of current river flow divided by a fixed parameter value defined by *Control Flow.Value*. If the parameter value is set to zero in this method, this has the effect of creating an unlimited resource state making all water from this source available on Pass 4.
- **Sequence value** – Resource state determined as the ratio of current river flow divided by a value taken from the sequence *Control flow*.

The effect of the control flow is that on pass 4 (excess water pass) water can be abstracted until the river flow falls to the control flow, any water remaining for abstraction is then available for pass 5 if required.

## Control flow.Type, Control flow.Value (Bulk Supply)

The control flow is used to determine the component's resource state, which in turn controls how much excess water (water that can be supplied on pass 4) is available. These two parameters provide alternative methods of assessing the control flow.

*Control flow.Type* can take one of the following values:

- **None** – Resource state is invalid, effectively infinite, which implies that all available water can be supplied on pass 4.
- **Parameter value** – Resource state determined as the ratio of maximum available supply divided by a fixed parameter value defined by *Control Flow.Value*.
- **Sequence value** – Resource state determined as the ratio of maximum available supply divided by a value taken form the sequence *Control flow*.

The effect of the control flow is that on pass 4 (excess water pass) the Bulk Supply can be "drawn down" to leave an amount equal to the control flow, which is then available for pass 5 if required.

## Control flow.Type, Control flow.Value (Groundwater)

The control flow is used to determine the component's resource state, which in turn controls how much excess water (water that can be supplied on pass 4) is available. These two parameters provide alternative methods of assessing the control flow.

*Control flow.Type* can take one of the following values:

- **None** – Resource state is invalid, effectively infinite, which implies that all available water can be supplied on pass 4.
- **Parameter value** – Resource state determined as the ratio of maximum available supply divided by a fixed parameter value defined by *Control Flow.Value*.
- **Sequence value** – Resource state determined as the ratio of maximum available supply divided by a value taken from the sequence *Control flow*.

The effect of the control flow is that on pass 4 (excess water pass) the Groundwater can be "drawn down" to leave an amount equal to the control flow, which is then available for pass 5 if required.

### Cost.Cost per Ml

The cost applied by this Component for each megalitre of water passing though it.

### Cost.Cost per Ml - forward

The cost applied by this Component for each megalitre of water passing though it in the forward direction.

### Cost.Cost per Ml - reverse

The cost applied by this Component for each megalitre of water passing though it in the reverse direction.

### Cost.Fixed cost

The fixed cost of this Component for one day.

### Cost.Fixed cost - forward

The fixed cost of this Component for one day when water is flowing in the forward direction.

### Cost.Fixed cost - reverse

he fixed cost of this Component for one day when water is flowing in the reverse direction.

### Cost.Weighting

Costs used by the model in calculating which source of water to use, are multiplied by this factor to influence the way water is allocated. Where there is *excess* water, cheaper water is used if possible This factor is normally set to 1 which implies no cost weighting. If set less than one, water passing though this Component is taken by the model to be less expensive during the allocation calculations. If greater than 1, water is considered to be more expensive in the allocation calculations.

Costs reported as results by the model do not have cost weighting factors applied. As such, they are the real costs.

### Cost.Weighting - forward

Costs used by the model in calculating which source of water to use, are multiplied by this factor to influence the way water is allocated when water is flowing in the forward direction. Where there is *excess* water, cheaper water is used if possible This factor is normally set to 1 which implies no cost weighting. If set less than one, water passing though this Component is taken by the model to be less expensive during the allocation calculations.

If greater than 1, water is considered to be more expensive in the allocation calculations.

Costs reported as results by the model do not have cost weighting factors applied. As such, they are the real costs.

### Cost.Weighting - reverse

Costs used by the model in calculating which source of water to use, are multiplied by this factor to influence the way water is allocated when water is flowing in the reverse direction. Where there is *excess* water, cheaper water is used if possible This factor is normally set to 1 which implies no cost weighting. If set less than one, water passing though this Component is taken by the model to be less expensive during the allocation calculations. If greater than 1, water is considered to be more expensive in the allocation calculations.

Costs reported as results by the model do not have cost weighting factors applied. As such, they are the real costs.

### Demand.Excess flow is natural

Any water released in excess of that requested by a downstream demand can be categorised as either *natural* or *release*. This could determine whether or not this excess amount was available for abstraction. Typically setting the *Demand.Scale factor* to greater than one creates this excess release.

### Demand minima.Enforce limit

Whether or not to enforce the maximum amount this component will supply water for demand centre input minimum flow purposes.

### Demand minima.Reservation limit

The maximum amount this component will supply water for demand centre input minimum flow purposes when the parameter Demand minima.Enforce limit is set to True.

### Demand.Route to supplies

Whether or not this regulator is able to support abstractions to supply.

### Demand minima.Scaling factor

Scale factor to apply to the requests for demand centre input minimum. This parameter is set to a value between zero and one. For example a value of 0.25 indicates that this source is able to supply one quarter of the total requested demand centre input minimum. Each demand centre should therefore be connected to sources whose cumulative value of this parameter is no less than one.

## Demand.Scale factor

The factor that any downstream demands are multiplied by to determine the release amount. Typically this may be greater than 1 to allow for a release inefficiency.

## Demand.Scaled excess

This parameter only has effect when parameter "Demand.Scale factor" is set greater than 1. Downstream indirect demands are scaled by this factor and the sources attached to the regulator try to supply this increased amount. The "Demand.Scaled excess" parameter controls how the scaled supply is utilisised.

This parameter can take one of three value:

1. Add to river immediately
2. Hold back if available
3. Hold back always.

"Add to river immediately" adds the excess to the river immediately. This means the excess water could be used further downstream on the same day. If water is not released immediately it is released on "FinishDay" which means it would be very unliley the excess could be abstracted the same day.

"Hold back if available" holds water back to "FinishDay", but the amount held back is reduced if there is not enough supply to provide the excess amount in full.

"Hold back always" holds water back to "FinishDay", but the amount held back is not reduced if there is not enough supply to provide the full demand. In this case the supply amount is reduced to ensure the "Demand.Scale factor" ratio is preserved.

## Demands: diversion.Max d/s delay

When the Diversion parameter *Operating.Mode* is set to *Demand mode* the Diversion component queries downstream to find the releases needed to satisfy any demands, in order to determine the optimum amounts to send to each outflow arm.

This parameter controls how far the Diversion queries down the diversion arm, in terms of days delay, when querying for the amounts required.

## Demands: diversion.Max d/s flow constraints

When the Diversion parameter *Operating.Mode* is set to *Demand mode* the Diversion component queries downstream to find the releases needed to satisfy any demands, in order to determine the optimum amounts to send to each outflow arm.

This parameter controls how far the Diversion queries down the diversion arm, in terms of the number of flow constraints to inspect, when querying for the amounts required.

## Demands: main arm.Max d/s delay

When the Diversion parameter *Operating.Mode* is set to *Demand mode* the Diversion component queries downstream to find the releases needed to satisfy any demands, in order to determine the optimum amounts to send to each outflow arm.

This parameter controls how far the Diversion queries down the main arm, in terms of days delay, when querying for the amounts required.

## Demands: main arm.Max d/s flow constraints

When the Diversion parameter *Operating.Mode* is set to *Demand mode* the Diversion component queries downstream to find the releases needed to satisfy any demands, in order to determine the optimum amounts to send to each outflow arm.

This parameter controls how far the Diversion queries down the main arm, in terms of the number of flow constraints to inspect, when querying for the amounts required.

## Determinand level.[Determinand n]

The fixed level of each determinand in the water supplied at each input connection.

## Determinand limit.[Determinand n]

The fixed output limit (quality) for each determinand.

## Direction.Algorithm

This parameter sets the method that is used to determine the direction of flow in bi-directional components located in the supply network each day. Possibilities are:

**None** – The direction remains the same as set by the state *Flow direction.Current value* at the start of the run. Use this method to force a direction for a model run. It is also a convenient method to use when using VBA code to set the direction.

**Alternate** – The direction switches regularly according to values set in the states *Flow direction.Hold period* and *Flow direction.days since reversal*.

**Best resource state** – The direction is set each day by looking at all routes passing through the component in both direction. The direction of the route that has the best resource state at its source is the direction of flow for that day.

**Mean resource state** – The direction is set each day by looking at all routes passing through the component in both direction. The direction of the routes that have the best mean resource state their sources is the direction of flow for that day.

**Lowest cost** – The direction is set each day by looking at all routes passing through the component in both direction. The direction of the route that has the lowest cost is the direction of flow for that day.

**Mean cost** – The direction is set each day by looking at all routes passing through the component in both direction. The direction of the routes that have the best mean cost is the direction of flow for that day.

## Fail.At dead water level

Report an end of day failure if the Reservoir storage is below the dead water level.

## Fail.At demand saving level

Report an end of day failure if the Reservoir storage is at or below the demand saving level specified by this parameter.

## Fail.At emergency storage level

Report an end of day failure if the Reservoir storage is below the emergency storage level.

## Fail.Criterion

Difference allowed before Component fails to meet demand, so as to allow for rounding errors.

## Fail.If demand not met

This Component will report a failure to Aquator if its demand is not met on any day.

## Fail.When additional outflow not met

Report an end of day failure if the additional outflow released is less than the required additional outflow release

## Fail.When compensation not met

Report an end of day failure if the compensation water released is less than the required compensation release

### Fail.When hydropower not met

Report an end of day failure if the hydropower released is less than the required hydropower release

### Fail.When irrigation not met

Report an end of day failure if the irrigation released is less than the required irrigation release.

### Flow constraint.Failure margin

This sets the tolerance on reporting a flow constraint failure.

### Flow constraint.Report failure

This parameter allows any breaking of the prescribed flow or maintained flow rules to be reported as failures by the component to Aquator at the end of each day.

### Flow constraint.Safety margin

This is a fixed amount that is added to any prescribed flow or maintained flow as a safety margin. For example if a prescribed flow were set at 120 Ml/d and safety margin set to 5Ml/d, no abstraction would take place below a flow of 125 Ml/d.

### Flow constraint.Type

Flow constraints can restrict the amount of water that can be taken for *direct* abstraction. A flow constraint can operate in one of three ways, determined by the value of this enumerated parameter:

**None**. All available water can be abstracted from the river.

**Maintained flow**. Abstraction can take place while the river flow downstream of the Abstraction or at a Gauging Station is at or above the flow constraint value. Earlier in the day upstream regulators may have added water to the river to meet these maintained flow constraints but at the point of abstraction no account is taken of whether this was done or not. The rule is simply that the downstream flow must not fall below the maintained flow *value due to abstraction at the time the abstraction is made*. If the river flow is below this value then no water is available for *direct* abstraction (as described elsewhere, *indirect* abstraction is not constrained by maintained flow constraints).

**Prescribed flow**. This is similar to the maintained flow case but relaxed by taking into account whether water has been added by upstream regulators earlier in the day. Abstraction can take place while the river flow downstream of the Abstraction or at a

Gauging Station is at or above the flow constraint value or the natural flow, whichever is less. This implies that water added to the river by an upstream regulator can be abstracted even if the river flow then falls below the flow constraint value, as long as the natural flow is not reduced below what it would have been with no abstraction. Upstream regulators will not add water to meet a prescribed flow value, they (optionally) only add water to meet the expected demand and any maintained flow constraints. Again, prescribed flow constraints only affect *direct* abstraction, not *indirect* abstraction.

### Flow constraint.Use sequence

This parameter determines whether the *Flow constraint.Value* parameter of the component's *Flow constraint* sequence is the source of either the Prescribed flow or Maintained flow.

### Flow constraint.Value

This is the value of either the Prescribed flow parameter or Maintained flow parameter depending on the setting of the *Flow Constraint.Type* parameter described above.

### Flow.Maximum

The absolute upper limit to the maximum flow available on this connector. Normally any licence on the supply to this connector restricts the actual maximum flow.

### Flow.Offset

The constant to be added to the flows. Catchment flow today (CatchmentFlow) is calculated by the formula:

CatchmentFlow = ClimateChangeScalingFactor
x ( (*Flow.Scaling* x *SequenceFlow*)
+ *Flow.Offset*)

where *SequenceFlow* is the value of flow today taken from the time series or profile.

### Flow.Scaling

The scaling factor to apply to flows. Catchment flow today (CatchmentFlow) is calculated by the formula:

CatchmentFlow = ClimateChangeScalingFactor
x ( (*Flow.Scaling* x *SequenceFlow*)
+ *Flow.Offset*)

where *SequenceFlow* is the value of flow today taken from the time series or profile.

### General.Apply demand saving

If this parameter is set to *True*, demands are reduced by the current demand saving factor. If set to *False* demands remain unchanged by demand saving in force elsewhere in the model.

### General.Demand

The single, fixed, value of demand in Ml which is multiplied by the appropriate demand factors to give the daily demand in Ml.

### General.Demand factor

The overall demand factor to apply to all demands, from whatever source they have been derived.

### General.Percent return

The percentage of the supply that is to be returned to the river system from a Demand Centre river out-connector. This represents *Effluent Return* from a Demand Centre. One or more river type out-connector must be added to the Demand Centre to allow these returns (right click on the Component and select from the context menu). These parameters are located on each of the DC's river out-connectors.

### General.Return is natural flow

Aquator records river flow in three categories; **natural**, **releases** and **abstractions**. This parameter determines whether any effluent returned to the river system should be in the category natural or release. The category can determine whether or not this water is abstracted downstream.

### Generation.Energy per Ml

The energy generated by this Component for each megalitre of water passing though it.

### Income.Daily Fixed cost

The fixed cost of this Component for one day.

### Income.Income per Ml

The income generated by this Component for each megalitre of water passing though it.

### Is natural flow.Additional release

Aquator records river flow in three categories; natural, releases and abstractions. This parameter determines whether any *Additional* releases should be in the category *natural* or *release*. The category can determine whether or not this water is abstracted downstream.

### Is natural flow.Compensation release

Aquator records river flow in three categories; natural, releases and abstractions. This parameter determines whether any *Compensation* releases should be in the category *natural* or *release*. The category can determine whether or not this water is abstracted downstream.

### Is natural flow.Flood drawdown release

Aquator records river flow in three categories; natural, releases and abstractions. This parameter determines whether any *Flood drawdown* releases should be in the category *natural* or *release*. The category can determine whether or not this water is abstracted downstream.

### Is natural flow.Hydropower release

Aquator records river flow in three categories; natural, releases and abstractions. This parameter determines whether any *Hydropower* releases should be in the category *natural* or *release*. The category can determine whether or not this water is abstracted downstream.

### Is natural flow.Irrigation release

Aquator records river flow in three categories; natural, releases and abstractions. This parameter determines whether any *Irrigation* releases should be in the category *natural* or *release*. The category can determine whether or not this water is abstracted downstream.

### Is natural flow.Spill

Aquator records river flow in three categories; natural, releases and abstractions. This parameter determines whether any *Spill* should be in the category *natural* or *release*. The category can determine whether or not this water is abstracted downstream.

### Income.Weighting

Net costs by the model in calculating which source of water to use, are multiplied by this factor to influence the way water is allocated. Where there is *excess* water, cheaper water is used if possible This factor is normally set to 1 which implies no income weighting. If set less than one, water passing though this Component is taken by the model to be less worthwhile (in terms of income generation) during the allocation calculations. If greater than 1, water is considered to be more worthwhile in the allocation calculations.

## Leakage flows.Enforce limit

Whether or not to enforce the maximum amount this component will supply water for leakage purposes.

## Leakage flows.Reservation limit

The maximum amount this component will supply water for leakage purposes when the parameter *Leakage flows.Enforce limit* is set to *True*.

## Leakage.Leak at zero flow

If this option is set to *True*, the link leaks water even if the flow in the link for supply is zero. This simulates the use of a control valve at the downstream end of the link. If the control valve is located at the upstream end of the link, this option should be set to *False*.

## Leakage.Leak at zero flow - forward

If this option is set to *True* then, when the flow direction for the day is in the forward direction, the bidirectional link leaks water even if the flow in the bidirectional link is zero. This simulates the use of a control valve at the downstream end (forward direction) of the bidirectional link. If the control valve is located at the upstream end (forward direction) of the bidirectional link, this option should be set to *False*.

## Leakage.Leak at zero flow - reverse

If this option is set to *True* then, when the flow direction for the day is in the reverse direction, the bidirectional link leaks water even if the flow in the bidirectional link is zero. This simulates the use of a control valve at the downstream end (reverse direction) of the bidirectional link. If the control valve is located at the upstream end (reverse direction) of the bidirectional link, this option should be set to *False*.

## Leakage.Link length

The length of the link in km for the purpose of calculating leakage.

Leakage = Leakage.Link length x Leakage.Leakage per km

## Leakage.Loss rate

The leakage in Ml/d for each km of link length.

Leakage = Leakage.Link length x Leakage.Loss rate

## Leakage.Loss rate - forward

The leakage in Ml/d for each km of bidirectional link length when flow is in the forward direction.

Leakage = Leakage.Link length x Leakage.Loss rate

## Leakage.Loss rate - reverse

The leakage in Ml/d for each km of bidirectional link length when flow is in the forward direction.

Leakage = Leakage.Link length x Leakage.Loss rate

## Level.Relationships

This parameter that specifies the storage, surface area, spill amount and seepage over the full range of water levels experienced at the reservoir. An example is as follows:

| Level (m) | Area (sq km) | Storage (Ml) | Spill (Ml/d) | Seepage (Ml/d) |
|---|---|---|---|---|
| 18 | 2 | 120000 | 1020.6 | 0 |
| 16 | 1.7 | 115000 | 423.5 | 0 |
| 13 | 1.4 | 110000 | 85.5 | 0 |
| 10 | 1 | 100000 | 0 | 0 |
| -15 | 0.8 | 70000 | 0 | 0 |
| -40 | 0.4 | 50000 | 0 | 0 |
| -90 | 0.01 | 0 | 0 | 0 |

The use of this table in general and for defining spill in particular is described under the description of the Reservoir component.

The table must be sorted so that Level decreases row by row. Consequently “Storage” must also decrease with row number.

## Limits.Daily min

The minimum flow that this Component wishes to support. Minimum flows can only be supported if there is sufficient demand to support the minimum and constraints elsewhere in the supply system allow.

## Limits.Daily max

The maximum flow that can occur on any day. The actual flow may be lower than this value if it reduced by either the current monthly maximum limit or a lower demand from the supply system.

### Limits.Enforce max/min flow/capacity

When set to False the maximum flow forward and reverse parameters are ignored. When set to True the maximum flow forward and reverse parameters are enforced.

### Limits.Max flow

The maximum flow that can occur on any day. The actual flow may be lower than this value if it reduced by either maxima elsewhere in the system or a lower demand from the supply system.

### Limits.Max flow - forward

The maximum flow through a bidirectional link that can occur on any day when flow is in the forward direction. The actual flow may be lower than this value if it reduced by either maxima elsewhere in the system or a lower demand from the supply system.

### Limits.Max flow - reverse

The maximum flow through a bidirectional link that can occur on any day when flow is in the reverse direction. The actual flow may be lower than this value if it reduced by either maxima elsewhere in the system or a lower demand from the supply system.

### Limits.Min flow

The minimum flow that this Component wishes to support. Minimum flows can only be supported if there is sufficient demand to support the minimum and constraints elsewhere in the supply system allow.

### Limits.Min flow - forward

The minimum flow that this bidirectional link wishes to support when flow is in the forward direction. Minimum flows can only be supported if there is sufficient demand to support the minimum and constraints elsewhere in the supply system allow.

### Limits.Min flow - reverse

The minimum flow that this bidirectional link wishes to support when flow is in the reverse direction. Minimum flows can only be supported if there is sufficient demand to support the minimum and constraints elsewhere in the supply system allow.

## Limits.Month n (xxx) max

The maximum flow that can occur on any day in the month. The actual flow may be lower than this value if it reduced by either the daily maximum or a lower demand from the supply system.

## Losses.Fixed loss

The volume of water that is lost from the system by this Component each day.

## Losses.Percent loss

The percentage of water passing through this Component which is lost from the system.

## Minimum flows.Enforce limit

Whether or not to enforce the maximum amount this component will supply water for supply link minimum flow purposes.

## Minimum flows.Reservation limit

The maximum amount this component will supply water for supply link minimum flow purposes when the parameter *Minimum flows.Enforce limit* is set to *True*.

## Minimum supply.Use profile

Set to True to use the profile defined under the connector's sequence *Minimum demand profile* to specify the minimum quantity of water which *must* enter the DC through this route. This parameter is located on each of the DC's supply in-connectors.

## Minimum supply.Constant value

Set to value of the minimum quantity of water which *must* enter the DC through this route. Set the parameter *Minimum supply.Use profile* to False to use this constant value rather than the sequence (profile) value. These parameters are located on each of the DC's supply in-connectors.

## Operating.Mode

A Diversion component can operate in one of three modes, as selected by this parameter.

**Approx rule** This is the legacy mode and backwards-compatible with versions of Aquator prior to 3.0, in which the diversion rule is only approximately enforced. The major reasons for this were (a) performance and (b) the problem that the built-in rule does not always have a unique inverse solution i.e. the diverted flow is constant while the inflow can change.

**Exact rule** This attempts to enforce the diversion rule exactly, at the expense of greater execution time. The problem described in the previous paragraph - whereby the inverse operating rule may have no unique solution - is solved with an additional constraint: to compute the change in inflow required for a requested change in diverted flow, the inflow closest to the current inflow is used if there are a range of inflow values that would satisfy the request.

**Demand mode** In this mode the diversion rule is not enforced. Instead the Diversion queries downstream what releases are required on each arm, and diverts water in proportion to those demands.

## Operation.Allow direct abstraction

If set to *True* abstractions can take place directly from the river so long as no flow constraints are broken.

## Operation.Allow indirect abstraction

If set to *True* abstractions can take place indirectly by requesting releases from an upstream source connected to the river system (typically using a *Regulator* component).

## Operation.Demand saving

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

## Operation.Minimum flows can overfill.

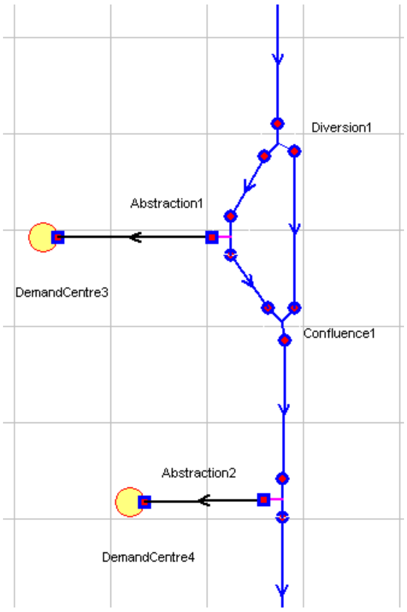
Normally a reservoir stops filling itself from supply when it is full or reaches the fill control curve. However if there is supply to a reservoir that has a route with a minimum flow set, this parameter, when set to *True*, allows the minimum flows to take place, even though they will probably result in the storage rising above the fill control curve and perhaps spill.

## Operation.Use emergency storage

If set to *True*, the Reservoir will use the parameter *Storage.Abs dead water level* as the minimum operating level. If set to *False*, the parameter *Storage.Abs emergency level* is used as the minimum operating level.

## Options.Anabranch detection

A diversion and a confluence connected together as illustrated below form what is known as an anabranch:




If this parameter is set to *True* then the confluence and the upstream diversion will operate in such a way as to optimise the supply of water to the two abstractions.

## Options.Animate on

Set to True if the Component is to provide day by day animation as the model runs. An example of this 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.

## Options.Animate history

If this parameter is available and set to True the component is to show the recent history of the simulation which is updated day by day as the model runs. An example of this a Reservoir which can show its calculated storage for the previous year graphically on the schematic.

Model execution time is increased when this option is on.

## Options.Diagnostics on

This is a model debugging option which helps a user understand how Aquator makes decisions on allocation of water. This option is only active if the model parameter of the same name is set to *True*. On each day the model is single stepped components with the option set to *True* write information into the model run

*Diagnostics log* detailing decisions made. Normally this option should be set to *False*.

### Options.Enabled

When enabled the Component operates normally. Setting this option to *False* effectively removed the Component from the system during model execution. It is recommended that if one or more components 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 Component 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.Forecasting on

This should be set to *True* when the component is to participate in forecasting. The model parameter of the same name must also be *True*.

When forecasting is off regulators take no account of downstream abstractions and gauging stations which are separated from the regulator by one or more reaches with a delay of 1 day or greater.

When forecasting is on for the components concerned then a regulator and an abstraction separated by a time delay, or a regulator and a gauging station separated by a time delay, will cooperate to make river flow predictions and hence the regulator may make releases for use in days after the current day.

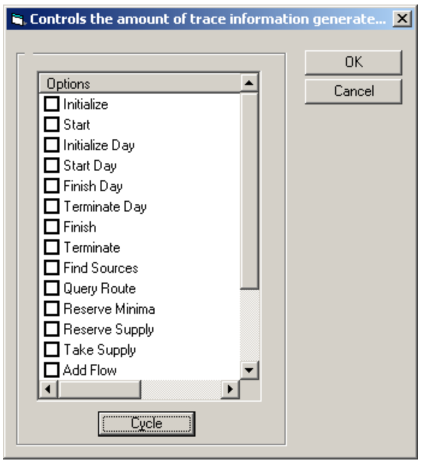
Forecast releases may be made to support maintained flow constraints and predicted abstractions, just as in the case of no delay. If the component does not need to take part in forecasting, this parameter should be set to *False* to improve execution time.

### Options.Suppress warnings

If this logical (boolean) parameter is set to True then any warnings that would be added to the model run log are suppressed. This applies particularly if the *Aqua Solver* optimiser is enabled and the component has a non-zero fixed loss.

## Options.Trace flags

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




## Options.Trace on

When set to *True*, Component events are logged in the *Trace log*. This is useful when debugging a system to ensure it is behaving as required. Trace information is only generated while single-stepping. The trace log is verbose and requires expert knowledge to interpret.

## Percentage take.Above flow constraint

For an *Abstraction* this is the percentage of the flow above the flow constraint that can be abstracted. Default value is 100%. See also the *Percentage take.Only apply locally* parameter.

For a *Gauging station* this is the percentage of the flow above the flow constraint that can be taken by abstractions upstream of the gauging station. Default value is 100%.

## Percentage take.Only apply locally

If this logical (boolean) parameter is set to True then the *Percentage take.Above flow constraint* parameter only applies locally i.e. to the amount supplied from this abstraction. Otherwise the *Percentage take.Above flow constraint* parameter applies to all upstream abstractions as well.

## Predicted release.Amount

If the *Predicted release.method* parameter is set to *Parameter value* then the value of this *Predicted release.Amount* parameter is used for the prediction.

## Predicted release.Minimum delay

When the *Predicted release.Method* parameter is *Query downstream*, this parameter controls how far downstream the regulator queries in order to make a prediction of how much it will release later in the day.

## Predicted release.Maximum delay

When the *Predicted release.Method* parameter is *Query downstream*, this parameter controls how far downstream the regulator queries in order to make a prediction of how much it will release later in the day.

## Predicted release.Method

In a model with multiple regulators it can occasionly be useful if one regulator can ask another regulator to predict what it will later supply. Since recursion can obviously occur this facility should be used with care.

This parameter can be set to the following values.

**None** The usual case where the regulator makes no prediction. Most models can be set up in this way.

**Parameter value** Use the value of the *Prediction release.Amount* parameter.

**Sequence value** Use the value from the *Predicted release* sequence profile, if assigned

**Last requested release** Use yesterday's requested release as the prediction for today

**Last actual release** Use yesterday's actual release as the prediction for today

**Query downstream** The regulator will query downstream to find what it will be asked for. This is where recursion can occur in a model with multiple regulators.

## Predicted release.Scale factor

The value of this parameter is used to scale any predicted release. See the *Predicted release.Method* parameter for more information.

## Process water.Is natural flow

Aquator records river flow in three categories; natural, releases and abstractions. This parameter determines whether any *process water* returned to the river system should be in the category *natural* or *release*. The category can determine whether or not this water is abstracted downstream.

## Process water.Percent of demand

The percentage of water entering The Water Treatment Works that is used in processing and does not enter supply. This water is then returned to the river system via a river type out-connector added to the water treatment work.

## Pumping.Amount

A pump station which has a river type out-connector demands water from a supply or supplies via its in-connector and pushes the resulting flow into a river. There are three combinations of when this water is moved and how this demand is determined and the choice is governed by the value of this enumerated parameter which can take one of the following cryptic values.

**Demand (RO)** The demand is determined by either the time series or the profile of the demand sequence, if specified, otherwise the lower of the daily and monthly maximum pumping parameters.

This demand is moved in **Regulation Order (RO)**, that is to say, early in the day when river regulation takes place. The Pump Station will appear in the *Regulation and Demand Order* box on the *Parameters* tab of the *Model Setup Dialog* where its order with respect to other regulators may be set.

**Demand (AO)** The demand is determined by either the time series or the profile of the *Demand Sequence*, if specified, otherwise the lower of the daily and monthly maximum pumping parameters.

This demand is moved in **Advance Order (AO)**, that is to say, later in the day when demands are being satisfied. The Pump Station will appear in the *Advance and Demand Order* box on the *Parameters* tab of the *Model Setup Dialog* where its order with respect to other demands may be set.

**Release (RO)** The demand is determined by the Pump Station inquiring downriver how much water to add to meet (a) any maintained flow constraints, and (b) any demands on Abstraction components. If the model forecasting option is on then the amount to release can include forecast requirements for future days in the model run.

This demand is moved in **Regulation Order (RO)**, that is to say, early in the day when river regulation takes place. The Pump Station will appear in the *Regulation and Demand Order* box on the *Parameters* tab of the *Model Setup Dialog* where its order with respect to other regulators may be set.

### Pumping.Daily max

The maximum quantity that can be pumped on any day. The actual pumping may be lower than this value if it reduced by either the current monthly maximum pumping or by the effects of any constraints.

### Pumping.Efficiency

This parameters is intended for situations where groundwater is pumped into a watercourse to augment river flows and less than 100% of the quantity pumped reaches the downstream abstraction point. If the downstream demand was 100 Ml/d and the efficiency 80%, the quantity abstracted from the source would be 125 Ml/d.

### Pumping.Enforce max limit

When set to False the daily and monthly maximum flow parameters are ignored. When set to True the daily and monthly maximum flow parameters are enforced.

### Pumping.Month n (xxx) max

The maximum pumping that can occur on any day in the month. The actual pumping may be lower than this value if it reduced by either the daily maximum abstraction, the requirement of the prescribed flow or by the effects of any constraints.

### Prediction.Accuracy

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

### Reach.Fixed loss per km

Amount of water lost per km per day from the reach.

### Reach.Length

Length of reach in kilometres.

### Reach.Percent inflow loss

Amount of water lost as a percentage of the inflow to the Reach (after fixed loss, if any, is subtracted).

## 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 *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 *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 *Catchment* component.

## Reach.Travel time

The travel time (in days) for water to move from the upstream end of the reach to the downstream end.

If travel times for all reaches between an Abstraction Point and a prescribed flow site (for example, a gauging station) are set to zero, Aquator is able to maintain the prescribed flow. If one or more travel times are non zero, VBA is needed to ensure the prescribed flow ***n*** days ahead is maintained (where ***n*** is the total travel time).

## Release.Additional outflow

The additional outflow release to make. If additional outflow release varies with time, then specify either a profile or a time series for the sequence *Additional outflow*.

## Release.Compensation

The compensation release to make. If compensation release varies with time, then specify either a profile or a time series for the sequence *Compensation flow*.

## Release.Excess flow is natural

Whether or not any release made over and above that required for downstream abstraction is to be marked as natural river flow or a release quantity. See parameter *Release.Scale factor* for scaling up requested releases. Whether the flow is natural or not can determine if this water is available for downstream abstraction.

### Release.Failure margin

Margin allowed before reporting a failure to release (Ml/d)

### Release.Flood drawdown

The maximum irrigation release that can be made.

### Release.Hydropower

The maximum hydropower release that can be made.

### Release.Irrigation

The maximum irrigation release that can be made.

### Release.Maximum components

This parameter determines how far, downstream this component is willing supply releases for regulation. Distance is measured in terms of number of river type components.

### Release.Maximum delay

This parameter determines how far, downstream this component is willing supply releases for regulation. Distance is measured in terms of cumulative reach travel time.

### Release.Scale factor

The factor to scale any requested release by. For example if the required release was 100 Ml and the factor 1.2, the actual release would be 120 Ml.

### Release.Scaled excess

This parameter only has effect when parameter *Release.Scale factor* is set greater than 1. Downstream release demands are scaled by this factor and the sources attached to the regulator try to supply this increased amount. The *Release.Scaled excess* parameter controls how the scaled supply is utilisised.

This parameter can take one of three value:

1. Add to river immediately
2. Hold back if available
3. Hold back always.

**Add to river immediately** adds the excess to the river immediately. This means the excess water could be used further downstream on the same day. If water is not released immediately it is released on “FinishDay” which means it would be very unliley the excess could be abstracted the same day.

**Hold back if available** holds water back to “FinishDay”, but the amount held back is reduced if there is not enough supply to provide the excess amount in full.

**Hold back always** holds water back to “FinishDay”, but the amount held back is not reduced if there is not enough supply to provide the full release demand. In this case the supply amount is reduced to ensure the *Release.Scale factor* ratio is preserved.

## Release.Support river

Whether or not this regulator is able to support river flows.

## Rule.Enforce maximum

When set to True the value of parameter *Rule.Transfer maximum* is enforced.

## Rule not obeyed.Accuracy criterion

Optionally the Diversion component can report when the diversion rule is not obeyed. This parameter controls the criterion used to determine if the actual flows do not agree with the diversion rule.

## Rule not obeyed.Report status

if True then the Diversion component will report in the model run log if the diversion rule was not obeyed to some accuracy determined by the *Rule not obeyed.Accuracy criterion* parameter.

## Rule.Start threshold

The inflow above which diverted flow can commence.

## Rule.Transfer maximum

The maximum amount of the inflow that can be diverted. This is enforced if parameter *Rule.Enforce maximum* is True

## Rule.Transfer rate

The percentage of the inflow, above the *Start threshold*, that is to be diverted. This diverted flow is also subject to a maximum quantity (*Transfer maximum*).

## Scaling factor.Abstraction sequence

This scaling factor is applied on a daily basis to the sequence *Abstraction*.

## Scaling factor.Discharge sequence

This scaling factor is applied on a daily basis to the sequence *Discharge*.

## Sequence.Scale factor

The factor to scale the demands by that originate from a sequence.

## Seepage.Constant amount

If *Seepage.Method* is set to "Constant", the seepage amount each day is taken from this parameter in mm and multipled by the current surface area of the reservoir to get the seepage volume.

## Seepage.Destination

Depending on the value of this parameter, seepage water can either be lost from the system when it is set to "System loss" or kept in the system by selecting a river outflow connector for its destination.

## Seepage.Method

Seepage from the reservoir can be calculated in one of the following ways:

1. No seepage loss
2. Constant value in mm that is multipled by the current surface area of the reservoir to get the seepage volume
3. Percent of current storage
4. Level related amount
5. Sequence of values (as time series or repeating annual profile) in mm and then multipled by the current surface area of the reservoir to get the seepage volume
6. Sequence of values in Ml/d which define the seepage loss.

This parameter determines the method to be used. Please see section on seepage under the the main Reservoir component description.

## Seepage.Percent storage

If *Seepage.Method* is set to "Percent storage", today's seepage is calculated from this parameter multiplied by the storage at the start of the day (after the effects of rainfall and evaporation have been taken into account).

### Storage.Abs. dead water level / Storage.Rel. dead water level

The dead water level of the Reservoir expressed in either Ml (Abs.) or percentage of full (Rel.).

If one is input, the other is calculated and *vice versa*.

Note the correct syntax when referencing in *VBA*, e.g.

```
Parameters("Storage.Abs. dead water level")
```

### Storage.Abs. emergency level / Storage.Rel. emergency level

The emergency storage level of the Reservoir expressed in either Ml (Abs.) or percentage of full (Rel.).

If one is input, the other is calculated and *vice versa*.

Note the correct syntax when referencing in *VBA*, e.g.

```
Parameters("Storage.Abs. emergency level")
```

### Storage.Abs. failure margin / Storage.Rel. failure margin

The tolerance on detecting and reporting a failure when the reservoir storage drop to emergency and/or dead water level. Rounding error might leave the storage fractionally above one of these key levels and therefore not result in a failure being reported. For example if dead storage was 1000 Ml, and this parameter set to 0.01 Ml, failure would be reported at 1000.01 Ml or less. (This parameter can also take negative values.)

If one form of this parameter is edited, the other is calculated and *vice versa*.

Note the correct syntax when referencing in *VBA*, e.g.

```
Parameters("Storage.Abs. failure margin")
```

### Storage adjustment.Offset

The constant to be added to the *Storage adjustment* sequence. Storage adjustment today, **StorageAdjustment** is calculated by the formula:

*StorageAdjustment* =

(*Storage adjustment.Scaling* x *SequenceAdjustment*)

+ *Storage adjustment.Offset*

where **SequenceAdjustment** is the value of storage adjustment today taken from the time series or profile.

## Storage adjustment.Scaling

The scaling factor to apply to *Storage adjustment* sequence. Storage adjustment today, **StorageAdjustment** is calculated by the formula:

*StorageAdjustment* =

(*Storage adjustment.Scaling* x *SequenceAdjustment*)

+ *Storage adjustment.Offset*

where **SequenceAdjustment** is the value of storage adjustment today taken from the time series or profile.

## Supply.Amount

The quantity of water available for supply.

## Storage.Capacity

This parameter provides the storage capacity of the reservoir (i.e. top water level (TWL) or the level at which spill starts..

This single value parameter is linked to the value of storage where "Level" = zero in the Level.Relationships table parameter.

This parameter is read only so can only be used to view the capacity or make use of it in VBA code. If the capacity needs to be changed, please change it via the storage at TWL in the *Level.Relationships* parameter. Alternatively right click on the reservoir and use the Resrvoir Setup facility.

## Supply.Failure margin

This sets the tolerance on reporting a failure when the parameter *Supply.Must use entire amount* is set to *True*.

## Supply.Must use entire amount

Whether or not to try to force use of the total amount available. Failures are reported in the *Model Run Log* if *Supply.Report Failures* is True.

## Supply.Name

If the source of water for this input is form more than one supply, this parameter specifies which supply to use.

The best way to set this parameter is to use the Inputs tab in the *Blender Setup* dialog.

Not used if only one supply to the connector.

## Supply.Report failures

If True and *Supply.Must use entire amount* is True, then if the Bulk supply fails to supply all of the water demanded, the failure is reported in the *Model Run Log*.

## Upstream releases.Maximum delay

This parameter controls whether an Abstraction or Gauging Station responds when an upstream Regulator inquires how much water to put into the river during the river regulation phase (phase 2) of water movement. Gauging stations may have a maintained flow constraint which requires a release. Abstractions may have a maintained flow constraint but also may require a release to support *direct* abstractions later in the day, or on a later day (forecasting).

If the travel time between Regulator and Abstraction or Gauging Station exceeds this parameter value then the Abstraction or Gauging Station does not respond i.e. does not ask for water to be put into the river. This parameter and the *Upstream releases.Minimum delay* parameter together bracket the 'distance' away a Regulator must be be and thus may be used to select which Regulators support the Abstraction or Gauging Station.

## Upstream releases.Minimum delay

This parameter controls whether an Abstraction or Gauging Station responds when an upstream Regulator inquires how much water to put into the river during the river regulation phase (phase 2) of water movement. Gauging stations may have a maintained flow constraint which requires a release. Abstractions may have a maintained flow constraint but also may require a release to support *direct* abstractions later in the day, or on a later day (forecasting).

If the travel time between Regulator and Abstraction or Gauging Station is less than this parameter value then the Abstraction or Gauging Station does not respond i.e. does not ask for water to be put into the river. This parameter and the *Upstream releases.Maximum delay* parameter together bracket the 'distance' away a Regulator must be be and thus may be used to select which Regulators support the Abstraction or Gauging Station.

## Upstream releases.Prediction amount

During the river regulation phase (phase 2) Regulators optionally add water to the river to support  maintained flow constraints and/or *direct* abstractions that may take place later in the same day, or on a later day (forecasting). The predicted amount needed to support any *direct* abstraction is taken to be the value of this parameter if the *Upstream releases.Prediction method* is set as *Parameter value*.

## Upstream releases.Prediction method

During the river regulation phase (phase 2) Regulators optionally add water to the river to support  maintained flow constraints and/or *direct* abstractions that may take place later in the same day, or on a later day (forecasting). The predicted amount needed to support *direct* abstraction is taken to be one of three possible values, and the choice is controlled by this parameter, as follows:

**Parameter value**: A fixed value to be used each day (see parameter Upstream release.Prediction amount)

**Last abstraction**: The amount abstracted yesterday (the first day of the model run uses the state value Abstraction.Previous day)

**Last demand**: The total amount requested yesterday as a demand on the abstraction (the first day of the model run uses the state value Demand.Previous day)

## Upstream releases.Prediction scale factor

During the river regulation phase (phase 2) Regulators optionally add water to the river to support  maintained flow constraints and/or *direct* abstractions that may take place later in the same day, or on a later day (forecasting). This parameter optionally scales the predicted amount needed to support *direct* abstraction (see the *Upstream releases.Prediction method* parameter) by some factor, often greater than one in order to allow for some uncertainty in making the prediction.

## Warning.Min flow

Under certain circumstances it might not be possible to meet the minimum flow requirements of a link.

For example a link with a minimum flow of 10 Ml/d could, theoretically, be connected to a Water Treatment Works whose maximum capacity was set to 8 Ml/d. Alternatively, perhaps there was insufficient demand to support a flow of 10 Ml/d.

If this option is set to *True*, this will be reported at the end of each day as the *Status level* variable. i.e.:

Status level = Warning

## Water level.Calculation method / Water level.Rating table

Modelled and observed flows a gauging station can optionally be converted to water level. Whether or not flows are converted is determined by parameter *Water level.Calculation method*. If a rating table is to be used for the conversion, the parameter *Water level.Rating table* is used for this purpose. Both these parameters are explained under the heading **Water level** on the Gauging Station component.

## States

A *State* is 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.

### Actual release.Previous day

This state value is the regulator's actual release on the previous day of the model run. It can be sued as a predictor of todays release.

### Flow direction.Current value

The direction of flow through this component at the start of the model run. See parameter *Direction.Algorithm*.

### Flow direction.Days since reversal

The number of days that have passed since the direction of flow changed. See parameter *Direction.Algorithm*.

### Flow direction.Hold period

The number of days between changing direction of flow when parameter *Direction.Algorithm* is set to *Alternate*.

### Flow.Inflows

These state values are an array; the number of rows of which are equal to the travel time parameter (number of days). For example, if there were a travel time of two days, there would be two rows in this array. Each row of the array represents the reach inflow in the previous days with the last row holding today’s outflow. There are three columns to the array; *Inflow*, *Releases* and *Abstractions*. Inflow is the total (net) flow and is equal to the natural flow - abstractions + releases.

### Flows.Travel time

Travel time of river flows through this Component in days.

### Requested release.Previous day

This state value is the previous day's  requested release. It can be used as a predictor of today's release.

### State Routing Table

A read-only table of all supply routes leading to the Component.

### Storage.Abs. start value / Storage.Rel. start value

The initial value of Reservoir storage expressed in either Ml (Abs.) or percentage of full (Rel.).

If one is input, the other is calculated and *vice versa*.

Note the correct syntax when referencing in *VBA*, e.g.

```
Parameters("Storage.Abs. start value")
```

### Yesterdays.Abstraction

An Abstraction Component can use the abstraction made yesterday to determine its resource state today. If the amount of water available today above the prescribed flow is greater than yesterday’s abstraction, the resource state for the day is set greater than 1. If today’s available water is less than yesterday’s abstraction, the resource state is less than 1.

### Yesterdays.Demand

An Abstraction Component can use yesterday’s total demand to determine its resource state today. If the amount of water available today above the prescribed flow is greater than yesterday’s demand, the resource state for the day is set greater than 1. If today’s available water is less than yesterday’s demand, the resource state is less than 1.

### Yesterdays.Demand saving level

The demand saving level in force yesterday. This is used in conjunction the optional sequence *Demand saving start allowed* to determine whether demand saving can start on any day.

### Yesterdays.Supply

This state value holds the amount supplied on the day before the current day. It is used e.g. to smooth flow changes from day to day.

### Yesterdays.Supply per AO

This array-type state value holds the amount supplied on the day before the current day for each AO (Advance Order). It is used e.g. to smooth flow changes from day to day. The array is fixed size and has 1 column and 9 rows i.e. it holds the amount supplied for AO = 1 to AO = 9.

### Yesterdays.Supply per RO

This array-type state value holds the amount supplied on the day before the current day for each RO (Regulation Order). It is used e.g. to smooth flow changes from day to day. The array is fixed size and has 1 column and 9 rows i.e. it holds the amount supplied for RO = 1 to RO = 9.

## Variables

A *Variable* is 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.

### Bidirectional.Inflow

Inflow to the component via its bi-directional connector.

### Bidirectional.Net flow

Inflow minus the outflow to the component via its bi-directional connector. Values can be negative.

### Bidirectional.Outflow

Outflow from the component via its bi-directional connector.

### Climate.Evaporation

Evaporation from the Reservoir surface (before scaling)

### Climate.Evaporation (scaled)

Evaporation from the Reservoir surface after scaling with climate change factors

### Climate.Evaporation scaling

The evaporation climate change scaling factor

### Climate.Rainfall

Direct rainfall into the Reservoir (before scaling)

### Climate.Rainfall (scaled)

Direct rainfall into the Reservoir after scaling with climate change factors

### Climate.Rainfall scaling

The rainfall climate change scaling factor

### Connector.Blend fraction

The fraction of the total flow supplied on this connector.

### Connector.Flow

The flow through this connector.

### Connector.Maximum flow

The maximum flow allowed through this connector.

### Cost.Fill

The cost of filling this reservoir from other supplies.

### Cost.Supply

The cost of supplying water from this reservoir to demands.

### Demand.Actual amount

The total actual amount released each day to meet demand, may be less than the requested demand.

### Demand.Amount

The daily demand at this component.

### Demand.Requested amount

The total requested release each day to meet demand each day.

### Demand saving.Level

The demand saving level as an integer value. Zero indicated no demand saving in force.

### Demand saving.Threshold (n) & Demand savings.Threshold (n) (%)

The demand saving control curve sequence for Level ***n*** in Ml or as % full.

### Determinand level.[Determinand n]

For a Blender, this is the output level (quality) of each determinand.

For a Blender input connector, this is the level (quality) of each determinand in the water supplied by the connection.

### Determinand level.[Determinand n (% of limit)]

The output level (quality) of each determinand as a percentage of its limit.

### Determinand limit.[Determinand n]

The output quality limit of each determinand.

### Discharge.Climate change scaling

Climate change scaling factors applied.

### Discharge.Scaled amount

Discharge amount scaled by climate change scaling factors and flow scaling.

### Discharge.Total scaling

The climate change scaling factors multiplied by the flow scalingscaling factor.

### Discharge.Unscaled amount

The discharge before any scaling was applied.

### Flow.Amount

Amount of flow into, through or from this Component.

### Flow.Climate change scaling

Climate change scaling factors applied.

### Flow.Constraint

Flow constraint value for this Component.

### Flow.Direction

The direction of flow through this Component (1 = forward, 2 = reverse).

### Flow.Diverted flow

Diverted flow from this component.

### Flow.Downstream

Downstream flow from this Component.

### Flow.[Inflow]

Inflow to this Component. [Inflow] may be more specific such as [Inflow1].

### Flow.Main outflow

Main outflow from this component.

### Flow.Natural

Natural flow through this Component. I.e. total flow excluding abstractions and releases.

### Flow.Net

Total flow into this component (natural + releases – abstractions).

### Flow.Net inflow

Total flow into this component (natural + releases – abstractions).

### Flow.Net outflow

Total flow from this component (natural + releases – abstractions).

### Flow.Observed

Recorded or measured flow at this point.

### Flow.[Outflow]

Outflow from this Component. [Outflow] may be more specific such as [Outflow1].

### Flow.Total releases to rivers

The total of all Reservoir releases to rivers

### Flow.Total river inflow

The total of all river inflows to the Reservoir

### Flow.Upstream

Upstream flow into this Component.

### Flow.Upstream abstractions

Cumulative abstractions upstream of this Component.

### Flow.Upstream releases

Cumulative releases upstream of this Component.

### Generator.Energy

The energy generated by this Component.

### Generator.Income

The income generated by this Component.

### Inflow.Forward

Inflows in a forward direction only.

### Inflow.Forward- Reverse

Net inflows through the component. Values are negative when flow is in reverse direction.

### Inflow.Natural

The natural component of the river inflow.

### Inflow.Net

The total river inflow = Natural + Releases - Abstractions.

### Inflow.Reverse

Inflows in a reverse direction only.

### Leakage.Amount

Amount of water lost to leakage by this component.

### Level.Modelled

Calculated flow at a gauging station converted to water level. See heading **Water level** on the gauging station component.

## Level.Observed

Observed flow (from the *Observed flow* sequence) at a gauging station converted to water level. See heading **Water level** on the gauging station component.

## Main.Inflow

Inflow to the component via its uni-directional connector.

## Main.Outflow

Outflow from the component via its uni-directional connector.

## Operation.Blend result

The result of the blending operation each day with zero indicating a success.

## Operation.Control flow

Control flow can be is used to determine resource state at a number of components and is taken from either a fixed parameter or a sequence.

## Operation.Failure amount

This provides the actual amount by which the failure criterion was not met. If more than one failure criterion is enabled, this figure contains the maximum of all failure amount on any one day.

## Operation.Resource state

The state of the resource at the Component at the beginning of the day (i.e. before any water has been taken). A resource state of 1 is *normal*; values greater than 1 indicate the resource is in a better than normal state.  A resource state less than 1 indicates the resource is in a worse state than normal  If the resource state is greater than 1, the Component is then able to supply water on Pass 4 (i.e. when least cost water is being sought).

## 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 |

### Outflow.Forward

Outflows in a forward direction only.

### Outflow.Forward- Reverse

Net outflows through the component. Values are negative when flow is in reverse direction.

### Outflow.Natural

The natural component of the river outflow.

### Outflow.Net

The total river outflow = Natural + Releases - Abstractions.

### Outflow.Reverse

Outflows in a reverse direction only.

### Pumping.Amount

The amount pumped, including any inefficiency losses.

### Pumping.Loss

The quantity of water lost from this source due to inefficiencies or losses.

### Reach.Abstraction

The amount abstracted along this river reach.

### Reach.Discharge

The additional discharge added along this river reach.

### Reach.Loss

The amount lost along this river reach.

### Release.Actual amount

The total actual release each day to support river flows.

### Release.Additional outflow

The actual additional outflow release

### Release.Compensation

The actual compensation release

### Release.Flood drawdown

The actual flood drawdown release

### Release.Hydropower

The actual hydropower release

### Release.Irrigation

The actual irrigation release

### Release.Requested amount

The total requested release each day to support river flows.

### Release.Spill

The amount of spill from the Reservoir

### Required.Additional outflow

The required additional outflow release

### Required.Compensation

The required compensation release

### Required.Hydropower

The required hydropower release

### Required.Irrigation

The required irrigation release

### Reservoir.Area

The surface area of the reservoir in that corresponds to the end of day storage.

### Reservoir.Level

The level of the reservoir in that corresponds to the end of day storage. Levels are relative to the Top Water Level (TWL) with positive values indicating the reservoir was spilling at the end of the day. Negative values indicate the reservoir was not full at the end of the day.

### Return.Amount

The amount of water returned to the river system. This represents effluent return.#

### Seepage.Amount

The amount of water lost (or returned to the system elsewhere) by reservoir seepage.

### Storage.Adjustment

The storage adjustment applied to the reservoir. This will be normally be the daily value of the Reservoir sequence *Storage adjustment*. If any negative storage adjustment cannot be met because the reservoir is empty, this variable will contain the actual adjustment made and will therefore be greater than the sequence value.

### Storage.Calculated & Storage.Calculated (%)

Reservoir storage calculated by the model as storage in Ml or as % full.

### Storage.Control & Storage.Control (%)

The Aquator Reservoir control curve sequence in Ml or as % full.

### Storage.Dead water & Storage.Dead water (%)

The Reservoir dead water storage line in Ml or as % full.

### Storage.Emergency & Storage.Emergency (%)

The Reservoir emergency storage line in Ml or as % full.

### Storage.Flood & Storage.Flood (%)

The Reservoir flood drawdown control curve sequence in Ml or as % full.

### Storage.Hydropower & Storage.Hydropower (%)

The Reservoir hydropower control curve sequence in Ml or as % full.

### Storage.Irrigation & Storage.Irrigation (%)

The Aquator irrigation control curve sequence in Ml or as % full.

### Storage.Observed & Storage.Observed (%)

The observed (measured) Reservoir storage sequence in Ml or as % full.

### Supply.Amount

The amount of water passing from this Component through the supply network to demands or the amount reaching a demand.

### Supply.Amount pass ‘n’

Amount supplied on each model Pass.

### Supply.Available

The amount of water that is available for supply. Could be less than that actually used.

### Supply.Cost

The cost added at the end of the day by this component. Typically this would be the component’s fixed cost plus the cost per Ml multiplied by the supply amount originating from or passing into the component. If at a demand centre this will be the total cost of supplying that demand centre.

### Supply.Direct

Total amount supplied by direct abstraction on each model Pass.

### Supply.Direct pass 1, 2 3, 4, 5 & 6

Amount supplied by direct abstraction on each model Pass.

### Supply.From sources

The total of all supply inflows to the Reservoir

### Supply.From sources pass ‘n’

The total of all supply inflows to the Reservoir on each of the model Passes.

### Supply.Indirect

Toatl amount supplied by direct abstraction on each model Pass.

### Supply.[Inflow]

The amount of water entering the component. Maybe more specific such as [Inflow2] which is the supply entering by the second inflow.

### Supply.Loss

The amount lost to supply

### Supply.Maximum abstraction

The maximum abstraction allowed each day.

### Supply.[Outflow]

The amount of water leaving the component. Maybe more specific such as [Outflow2] which is the supply leaving by the second inflow.

### Supply.To demands

The total of all Reservoir abstractions to the supply system.

### Supply.To demands pass ‘n’

The total of all Reservoir abstractions to the supply system on each of the model Passes.

### Supply.Unsatisfied minimum

The difference between the minimum amount required on the input to the demand centre and that which was actually supplied.

### Treatment.Clear water return

The amount of clear water returned to the river system.

### Treatment.Loss

The amount of water lost in the treatment process.

### Treatment.Process water

The amount of process water used in the treatment process.

## 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.

### Abstraction

This optional sequence, defined as a profile or time series, allows an abstraction to take place on the river reach. The sequence value is multiplied by the parameter *Scaling factor.Abstraction* *sequence*. This abstraction is added to the fixed losses on the reach (i.e. the parameters *Reach.Fixed loss per km* and *Reach.Length* multiplied together).

### Additional outflow

Daily values of additional outflow. If neither a time series nor profile is specified here, the value of the parameter *Additional outflow* is used.

### Amount to supply

The amount that is available for supply.

### Climate change (Catchment)

The climate change factors to apply to the sequence selected to model Catchment flow.

### Climate change (Discharge)

The climate change factors to apply to the discharge inflows.

### Climate change - evaporation

The climate change factors to be applied to the evaporation sequence.

### Climate change - rainfall

The climate change factors to be applied to the rainfall sequence.

### Compensation flow

Daily values of compensation flow. If neither a time series nor profile is specified here, the value of the parameter *Compensation* is used.

### Control curve

Aquator control curve for the Reservoir. If the storage on any day is above this curve, there is an excess of water available from this source and this water is more likely to be used to meet demand.

### Control curve - fill

This control curve is used when the reservoir has one or more supply type in-connectors and defines the level at which filling of the reservoir by these in-connectors starts. If the current storage is below this control curve, filling takes place to try and raise the storage to the control curve. If the current storage is above this control curve, no filling takes place. If no control curve is defined, filling only stops when the reservoir is full.

### Control flow (Abstraction)

Control flow on any day supplied as a sequence. See the Resource state for Abstraction.

### Control flow (Bulk Supply)

Control flow on any day supplied as a sequence. See the *Resource state* for Bulk Supply.

### Control flow (Groundwater)

Control flow on any day supplied as a sequence. See the *Resource state* for Groundwater.

### Cost per Ml

Daily cost of supplying one mega litre.

### Demand factors

Factors that are applied to the fixed demand (see *Parameters General.Demand*) to give a daily value of demand.

### Demand sequence (Demand Centre)

Used as alternative to, and has precedence over, demands calculated using a fixed demand multiplied by a demand factor.

### Demand sequence (Pump Station)

Demands to be placed on the supply network via the pump station's in-connector. These demands are capped by the daily and monthly maximum parameters.

### Demand saving start allowed

This optional Boolean sequence, defined as a profile or time series, determines on a day to day basis whether demand saving can start if it not already turned on. This is used in conjunction with the state *Demand saving level.Yesterday*. If demand saving is already on and the Boolean value for a day is False, the demand saving level is allowed to rise, fall or stay the same on that day. This sequence is useful if you wish to inhibit the introduction of any demand saving in wet periods.

### Determinand n level

The level of each determinand in the water supplied at each input connection as a profile or time series. Can also be set from the **Limits and levels** tab of the *Blender Setup Form*.

### Determinand n limit

The output limit (quality) for each determinand as a profile or time series. Can also be set from the **Limits and levels** tab of the *Blender Setup Form*.

### Discharge

This optional sequence, defined as a profile or time series, allows an additional discharge to enter the top of the river reach. The sequence value is multiplied by the parameter *Scaling factor.Discharge sequence*. This discharge is added to the reach at the start of the day before any water is abstracted.

### Evaporation

Direct evaporation from the Reservoir surface.

### Flood drawdown

The Reservoir is drawn down to this curve, subject to maximum Discharge limits, for downstream flood alleviation purposes.

### Flow (Catchment)

The Catchment flow.

### Flow (Discharge)

The inflow discharge to the river.

### Flow constraint

This sequence provides a daily flow constraint value as an alternative to fixed parameter values when parameter *Flow constraint.Use sequence* is set true.

### Forward/Reverse cost per Ml

Daily cost of supplying one mega litre.

### Hydro drawdown

When the Reservoir level is above this control curve, releases for hydro power can take place.

### Irrigation drawdown

When the Reservoir level is above this control curve, releases for irrigation can take place.

### Income per Ml

The income generated by this Component for each megalitre of water passing though it as a profile.

### Level n control curve

The Reservoir control curve below which demand saving level ***n*** is reported by the Reservoir. Level 1 is a less severe condition than Level 2; consequently, the Level 1 curve should be above the Level 2 curve and the Level 2 curve above the Level 3 curve etc.

### Loss

This optional sequence, defined as a profile or time series, replaces the fixed value of loss obtained by multiplying the parameters *Reach.Fixed loss per km* and *Reach.Length* together. The sequence value is multiplied by the parameter *Scaling factor.Discharge sequence*. This discharge is added to the reach at the start of the day before any water is abstracted.

### Maximum abstraction

Maximum Abstraction allowed on any day supplied as a sequence.

### Minimum demand profile

This optional sequence is used to specify the minimum quantity of water which *must* enter the DC through this route. Set the parameter *Minimum supply.Use profile* to True to use this profile rather than the constant value defined by the parameter *Minimum supply.Constant value*. This sequence is located on each of the DC's supply in-connectors.

### Predicted release

A profile linked to this sequence is used to predict the release that will be made by the regulator.

### Prescribed flow

A prescribed flow (also known as the minimum residual flow - MRF) is that flow that must be in the river after any abstractions have taken place. If the flow in the river is below the prescribed flow just upstream of the Abstraction point, no Abstraction can take place. This sequence provides a daily value of prescribed flow.

## Rainfall

Direct rainfall input to the Reservoir.

## Observed flow

The observed (recorded) flow at the gauging station.

## Observed storage

The observed Reservoir storage.

## Seepage

The reservoir seepage loss applied if the reservoir parameter *Seepage.Method* is set to “Seepage sequence”. The value taken from this sequence is multiplied the current reservoir area to get the seepage volume each day.

## Seepage (Mld)

The reservoir seepage loss applied if the reservoir parameter *Seepage.Method* is set to “Ml/d sequence”. The value taken from this sequence is the seepage volume each day.

## Storage adjustment

If a time series or profile (in Ml storage) is assigned to this sequence, reservoir storage is adjusted at the start of the each day by the sequence amount. Values in this sequence can be either positive (to increase storage) or negative (to decrease storage). If there is insufficient storage in the reservoir at the start of the day to meet a negative adjustment, any additional inflow to the reservoir during the day is used to satisfy this adjustment before reservoir storage is increased. Negative adjustments take place until the reservoir is empty (i.e. below any emergency or dead water storage).