Ownership in Wetlands - SRG

Overview

Description and rationale

In some water resource systems water is shared between competing interests by the use of an ownership tracking mechanism. An ownership system is characterised by the separate treatment of each owner's water. The rationale for modelling water ownership, and the overall principles, are discussed in Ownership in Storages - SRG.

Wetland channels, modelled by wetland links (see Wetlands SRG for more information) in Source can connect:

- Wetland compartments
- A wetland and a river.

This SRG entry describes how the ownership of water moving via wetland channels can be determined in Source, and how this influences ownership of water where a wetland connects with a river. Requirements are summarised in Table 1. Ownership aspects within a wetland compartment (modelled by the storage node in Source) is covered separately in Ownership in Storages - SRG.

Table 1. Partner user requirements

No	Requirement
1	Ownership of water can be assigned, tracked and reassigned.
1.1	Ability to specify initial ownership of water at each location (all water must be assigned to an owner)
1.2	Ability to specify the transfer of ownership at a location, represented as a node in the river network.
1.3	Borrow and payback is supported, where owners share surpluses to owners that cannot meet their requirements, and can be paid back later.
1.4	In every model component, ownership is conserved when it is not explicitly transferred or exchanged, i.e. the following volume equation holds for each owner ***o***: $Storage_o = Inflow_o - Outflow_o - Diversion_o - Loss_o + Gain_o + Borrowed_o - Lent_o$
2	Water flowing from a river to a wetland on a wetland link is shared according to rules input by the modeller.
2.1	Flow from the river on a wetland link can be shared proportionally, or according to fixed ratio.
2.2	When flow from the river in a wetland link is shared proportionally, owners are assigned a share in proportion to their upstream inflow.
3	Water flowing into a river from a wetland link retains its ownership, i.e. is treated the same way as upstream inflow.
4	Water flowing out from a reservoir via a wetland link is shared according to rules input by the modeller.
4.1	Flow from a reservoir via a wetland link can be shared proportionally, or according to fixed ratio
4.2	When flow from a reservoir via a wetland link is shared proportionally, owners are assigned a share in proportion to the volume of their water in storage.
5	Water flowing into a reservoir via a wetland link retains its ownership, i.e. is treated the same way as upstream inflow.

Scale

The concept of spatial scale in the context of Ownership relates to the fact that it can apply to all or part of the length of a river system. Ownership status can be updated as often as at every model time step, or less often if required.

Principal developer

This version of modelling ownership in wetlands has been developed by eWater CRC for Source.

Scientific Provenance

Ownership has been modelled in predecessors to Source, such as IQQM and MSM, for many years. The concepts in these models have been updated and enhanced to suit the needs of Source.

Version

Source v3.8.8.

Dependencies

In addition to the dependencies applicable to wetlands, the minimum requirement is that there should be at least two water users and an Ownership system in the river system being modelled.

Availability/conditions

Automatically included with Source.

Table 2. Assumptions and Constraints

No	Assumption/Constraint
1	Owners cannot have a negative share of water in storage or transit
2	The sum of each owners' share of flow or storage volume at a model component will equal the total flow or storage volume for the corresponding component.
3	The direction of flow in a wetland link is the direction that has the highest flow volume over the time step.

Structure & processes

Theory

Overview

A wetland can be viewed as one or more water compartments joined together. The way in which wetlands are modelled in Source is described in detail in the Wetlands SRG. The components used are:

- Wetland Link: Represents connectors where the flow volume and direction are determined by the surface water elevation at each end.
- Storage Node: Wetland compartment (e.g. weir, reservoir, lake, pond).
- Hydraulic Connector Node: Point at which a wetland interacts directly with a river and the effect of the flow in the wetland links on the water elevation in the river is small enough to ignore.

In Source, the general rule for water ownership is that it is conserved as water moves from upstream to downstream. As the wetland link possesses no storage volume the ownership of water entering the link is equal to the ownership leaving it.

As wetland link flow can be in either direction, the ownership of flow on a wetland link is determined at the source of the flow. This source of flow may be a wetland compartment (Storage Node) or a river connection (Hydraulic Connector Node).

Wetland links

Outflow sharing arrangements are configured by the modeller at each end of a wetland link. The arrangements apply to flows leaving the node (and entering the wetland link) at the end at which the sharing arrangements are configured. Owners' shares may be specified as fixed or proportional:

- If they are fixed at one or both ends, the modeller configures each owner's ratio or percentage of the flow entering the wetland link from this end and this remains constant for the model run. At various times during the model run, some owners may not have sufficient water at the source node to sustain their fixed share of flow, while others will have a surplus. When this happens, owners with a deficit will borrow from those with a surplus. This borrow is accounted for, and may be paid back later (see Borrow and Payback - SRG for more information).
- If shares are defined to be proportional, each owner's share is recalculated in each model time step. This calculation differs according to the type of node connected to the nominated end of the wetland link:
  - Hydraulic connector node: Each owner's share is proportional to its current inflow from the upstream standard link:

Equation 1	$Share_{source}(l,i) = \frac{I_i}{I}$

where:

***Share*$_{source}$*(l,* i)** - Owner *i*'s share of outflow from the hydraulic connector along wetland link *l*
***I*$_i$** - Owner 's upstream inflow to the hydraulic connector over the current time step
I - Total upstream inflow to the hydraulic connector over the current time step

  - Storage node: Each owner's share is proportional to its current storage volume:

Equation 2	$Share_{source}(l,i) = \frac{V_i}{V}$

where:

***Share*$_{source}$*(l,* i)** - Owner *i*'s share of outflow from the hydraulic connector along wetland link *l*
***V*$_i$** - Owner *i*''s storage volume.
V - Total volume in the storage.

In a Source scenario, it is possible for a wetland link's 'downstream' node to be processed before the corresponding 'upstream' one. To address this issue, values of inflow or storage volume from the last time step are used to approximate the proportionally shared ownership.

For a wetland link *l*, an owner i's flow during the current time step (W_l^i) is:

Equation 3	$$W_l^i = Share_{source}(l,i) \times W_l$$

where:

***Share*$_{source}$*(l,* i)** - Owner *i*'s share of outflow from the hydraulic connector along wetland link *l*

W_l - Total wetland flow in a wetland link *l* during the current time step

Wetland nodes

An owner *i*'s total wetland flow volume entering/leaving a node over a time step (W_i) is the sum of its flow volume on all connected wetland links:

Equation 4	$$W_i = \sum_l W_l^i$$

where:

l - A wetland link connected to the wetland node

W_l^i - Owner *i*'s flow volume in wetland link *l* during the current time step (as calculated by equation 3).

Hydraulic Connector Node Calculations

An owner *i*''s downstream outflow at a hydraulic connector (O_i) is their upstream inflow minus their wetland flow:

Equation 5	$$O_i = I_i - W_i$$

where:

I_i - Owner *i*'s inflow at the hydraulic connector over the current time step

W_i - Owner *i*'s total wetland flow at the hydraulic connector over the current time step as calculated by equation 4.

An owner's downstream outflow could be negative if they are assigned a fixed share of wetland outflow that exceeds their upstream inflow. Ownership rules dictate that every owner has non-negative outflow. Hence, owners with a negative (deficit) downstream outflow volume must borrow from others with positive (surplus) flow. The surplus/deficit for each owner is their outflow volume:

Equation 6	$$Surplus_i = Max(0, O_i)$$

Equation 7	$$Deficit_i = Max(0, -O_i)$$

The borrow method (described in Borrow and Payback - SRG) will return the amount an owner borrows ($Borrowed_i$) and lends ($Lent_i$). The owner's outflow is then adjusted.

Equation 8	$$O_i = O_i + Borrowed_i - Lent_i$$

As flow processing ensures that total downstream outflow is non-negative, this adjustment will ensure every owner has non-negative outflow.

Storage Node Calculations

The storage ownership continuity equation described in Ownership in Storages - SRG is:

Equation 9	$V_2^i = V_1^i + I_i - C_i - P_i - F_i - IS_i - ES_i + B_i - O_i$

where:

V^i_2 - Owner 's volume of water in the reservoir this time step.

V^i_1 - Owner 's volume of water in the reservoir last time step.

I_i - Volume of inflow this time step belonging to owner *i*.

C_i - Net volume of water ceded by owner *i* this time step to all other owners, negative if this owner has ceded less water to other owners than received.

P_i - Proportional loss attributed to owner *i*, negative if a gain.

F_i - Fixed loss attributed to owner *i*, negative if a gain.

IS_i - Net internal spill of owner *i*, negative if spill into owner's share.

ES_i - External spill for owner *i*.

B_i - Total borrowed from other owners by owner *i*, negative if the owner is lending to other owners.

O_i - Volume of regulated water released this time step for owner *i*.

Flow to or from the storage on a wetland link is treated as a fixed loss (part of F_i), as it is not determined by current time step calculations at the storage:

- If the flow is shared according to configured ratio, the share is not changed by storage calculations
- If the flow is shared proportionally, the previous time step's storage volume is used.

Borrow calculations for the storage node are discussed in Ownership in Storages - SRG. They need no modification to cater for storages in wetlands when is defined as above.

Methodology

Variables used

Table 3. Common

Symbol	Purpose/Description	Units
i	Owner index	
t	Time step index – used for the current time step	
t - 1	Index of the previous time step.	

Table 4. Wetland link

Symbol	Purpose/Description	Units
Node1	'from' wetland node at one end of the link – the flow values are positive when flow comes from this node (configured).	n/a
Node2	'to' wetland node at the other end of the link – the flow values are negative when flow comes from this node (configured).	n/a
FixedShare (Source, i)	Owner *i*'s fixed flow share/ratio when flow is coming from the end of the wetland link (configured - total for all owners adds up to 1).	n/a
FlowSharing (Source)	Sharing method (fixed/proportional) when flow is coming from the end of the wetland link (configured).	n/a
Share(i)	Owner *i*'s share of flow in the wetland link (total for all owners adds up to 1).	n/a
Source	Node at the end of the wetland link that flow is coming from in the current time step.	n/a
Source.Type	Type of node at the end of the wetland link that flow is coming from in the current time step – 'Storage' or 'Hydraulic connector'	n/a
flow(t)	Wetland link's total flow volume in timestep *t*.	volume
flow(i, t)	Owner *i*'s volume of the wetland link's flow in timestep *t*.	volume

Table 5. Wetland storage

Property or Method	Purpose/Description	Units
F(i)	Owner *i*'s volume of losses that are fixed for the current time step in the storage.	
Volume(i, t-1)	Owner *i*'s volume of water in the storage at the end of the previous timestep (calculated by the standard storage model).	volume
Volume(t - 1)	Total volume of water in the storage at the end of the previous timestep (calculated by the standard storage model).	volume
WetlandLoss(i, t)	Total flow volume for owner *i* to/from wetland links connected to the storage for timestep *t*. (A positive value is an outflow to the wetland)	volume

Table 6. Hydraulic connector

Property or Method	Purpose/Description	Units
Inflow(i, t)	Inflow volume for owner, *i*, from a standard link upstream into the hydraulic connector for time step *t*	volume

Outflow(i, t)	Outflow volume for owner, *i*, to a standard link downstream of the hydraulic connector for time step *t*	volume
WetlandLoss(i, t)	Total flow volume for owner *i* to/from wetland links connected to the storage for timestep *t*. (A positive value is an outflow to the wetland)	volume
Borrowed(i)	The volume that owner, *i*, borrowed from other owners to meet their flow deficit.	volume
Lent(i)	The volume of downstream outflow that owner, *i*, lent to other owners with a deficit.	volume
Deficit(i)	The volume that owner, *i*, needs to borrow from other owners so that they do not have negative downstream outflow.	volume
Surplus(i)	Surplus (positive) downstream outflow for owner, *i*, that can be lent to other owners as required.	volume

Flow phase

Wetland link

For each model time step the following steps are performed after the wetland link flow rate has been calculated to determine wetland link owner values:

1. If this link has already been processed (***(flow, (i, t) not null***), exit here. (Ownership calculations only have to be done once on a wetland link).
2. Get the 'source' node that flow originates from this time step. Note that a positive flow value indicates that flow moves from *Node1* to *Node2*. (Node1, *Node2* are configured).
    - If ***flow(t) > 0, Source = Node1***
    - Otherwise ***Source = Node2***
3. Get the source node's outflow share. Last time step's values are used as ownership processing may not have been performed for the node as yet:
    - If the ***FlowSharing(Source) = 'Proportional'***
        - If ***Source.Type = 'Storage'***

Equation 10	$$Share(i) = \frac{Source.Volume(i, t-1)}{Source.Volume(t-1)}$$

        - Otherwise (hydarulic connector)

Equation 11	$$Share(i) = \frac{Source.Inflow(i, t-1)}{Source.Inflow(t-1)}$$

    - Otherwise (sharing is fixed)

Equation 12	$$Share(i) = FixedShare(Source, i)$$

4. For each owner: Apply the owner's share to the total to determine their flow volume.

Equation 13	$$flow(i, t) = Share(i) \times flow(t)$$

Wetland storage

The following method determines each owner's share of wetland loss in a storage, and adds it to their total fixed losses:

1. Determine total wetland flow per owner using the generic method for a wetland node (See Method Description section below).
2. Add each owner's share of total wetland flow to their share of fixed storage losses:
3. Use this fixed loss value in ownership processing as per Ownership in Storages - SRG.

Hydraulic connector

Each owner's upstream inflow to a hydraulic connector *Inflow(i)* equals the outflow from the link connected upstream (if none are connected, it is zero). To determine each owner's share of wetland loss and outflow the following steps are performed:

1. Determine total wetland flow per owner *WetlandLoss(i)* using the generic method for a wetland node (See Method Description section below).
2. Each owner's share of downstream outflow is its inflow plus wetland loss/gain:

Equation 14	$Outflow(i) = Inflow(i) + WetlandLoss(i)$

3. If any owner has a negative share of outflow, use the borrow method to bring its share to zero:
    a. Determine owner surpluses and deficits – this is simply their unmodified downstream outflow:

Equation 15	$Surplus(i) = Max(0, Outflow(i))$

Equation 16	$Deficit(i) = Max(0, -Outflow(i))$

    b. If any owner deficit > 0, use the Borrow method described in Borrow and Payback - SRG.
    c. Update every owner's outflows for volumes borrowed and lent:

Equation 17	$Outflow(i) = Outflow(i) + Borrowed(i) - Lent(i$

Method Description

Generic method to calculate wetland loss for a wetland node

To determine total wetland flow per owner *WetlandLoss(i)*:

For every connected wetland link

1. Run the wetland link's ownership processing – this determines *WetlandLink.flow(i, t)*
2. Add each owner's share of the wetland link's flow *WetlandLink.flow(i, t)* to their wetland flow total *WetlandLoss(i)*. The default 'upstream' node on a wetland link is *Node1*, so if the current flow value is positive, flow is moving away from this node.
    - If ***(this Node = WetlandLink.Node1)*** the current node has been treated as 'upstream', so:
      For every owner *i*

Equation 18	$WetlandLoss(i) = WetlandLoss(i) + WetlandLink.flow(i,$

    - Otherwise: (the node is 'downstream' so the flow is a gain)
      For every owner *i*

Equation 19	$WetlandLoss(i) = WetlandLoss(i) - WetlandLink.flow(i,$

Data

Input data

Details on data are provided in the Source User Guide.

Parameters or settings

Input parameters are summarised in Table 7.

Table 7. Wetland link: Ownership Parameters

Parameter Name	Parameter Description	Unit type	No. of values	Allowable values & validation rules	Default Value(s)
Source Node	Name of a node connected to the wetland link	n/a	2	Read only	Name of connected node
Flow sharing method	Indicates whether the flow from *Node* will be shared in fixed ratio or proportionally.	n/a	2	'Fixed Ratio' or 'Proportional'	Proportional
Flow sharing table: Owner	An owner in the wetland link's ownership system.	n/a	1 per owner in o. s.	Read only	Each owner in the storage's o.s.
Flow sharing table: Share	Owner's percentage share of outflow from *Node*.	%	1 per owner	Owner percentages must add up to 100%	Equal share of 100 per owner.

* **Note**: The initials o.s. refer to the current ownership system.

Output data

Recorded variables are listed in Table 8.

Table 8. Recorded variables: Wetland flow ownership

Model element	Parameter	Units	Variable /calculation	Freq.	Display format
Wetland link + owner	Share	%	***Share(i)***	Time step	Displayed as: Graph, Table, Statistics (min, max, average over the modelled time period)
	Wetland flow volume	volume	***WetlandLoss(i)***		