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CSIRO LAND and WATER

Murray Flow Assessment Tool
A Technical Description
(based on version 1.4)

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Client Report for the CRC for Freshwater Ecology

October 2003

COOPERATIVE RESEARCH CENTRE FOR FRESHWATER ECOLOGY

MURRAY-DARLING BASIN COMMISSION

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(based on MFAT version 1.4)

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Acknowledgements
The CSIRO MFAT development team was Dr Bill Young, Susan Cuddy, John Coleman and Felix Andrews. MFAT code was written by John Coleman and Felix Andrews.

Reference
This document should be referenced as:
Young, W.J., Scott, A.C., Cuddy, S.M. and Rennie, B.A. (2003) Murray Flow Assessment Tool – a technical description. Client Report, 2003. CSIRO Land and Water, Canberra.

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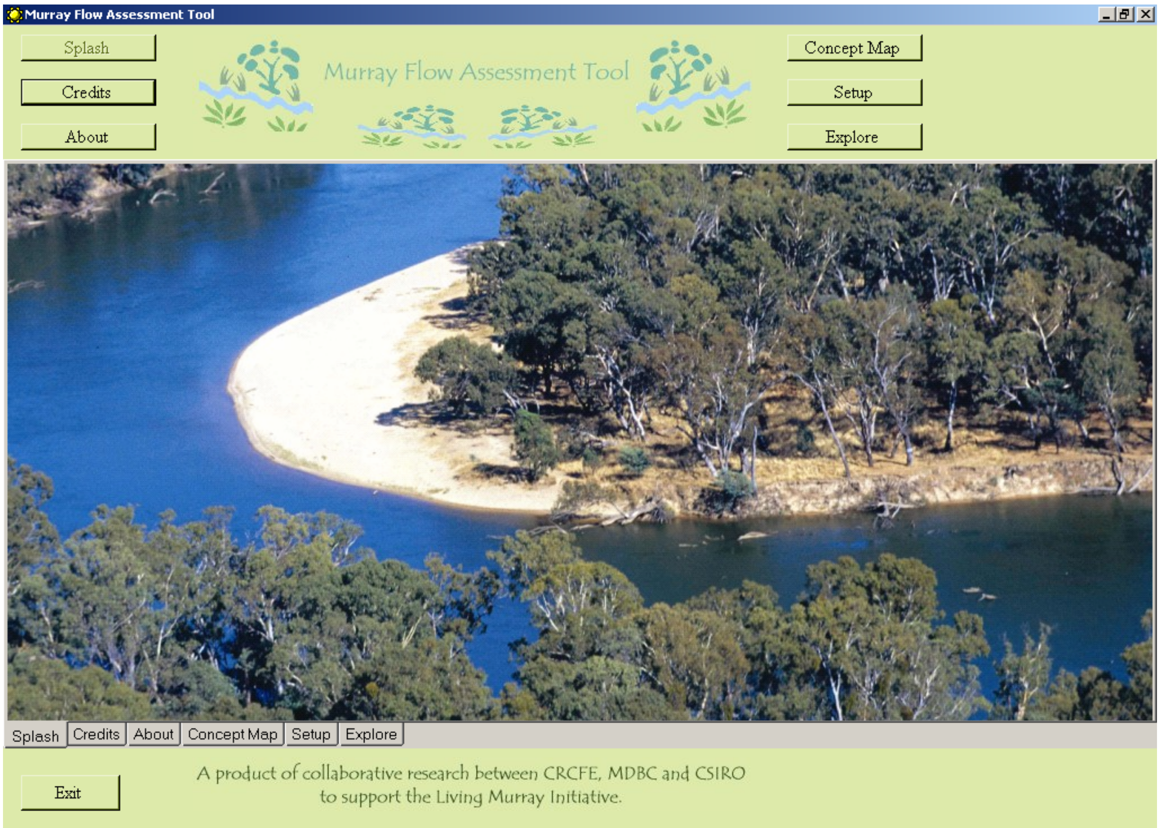
1 INTRODUCTION

The Murray Flow Assessment Tool (MFAT) is a software tool for predicting the ecological benefits/impact of different flow scenarios along the River Murray system. It was developed by CSIRO Land and Water for the Cooperative Research Centre for Freshwater Ecology (CRC FE) under contract to the Murray-Darling Basin Commission. The MFAT has been used to support the Scientific Reference Panel, an expert panel established by the CRC FE to undertake an assessment of three proposed environmental flow reference points for the *Living Murray Initiative*.

The structure and conceptualisation of the MFAT are largely based on the Environmental Flows Decision Support System (EFDSS) developed by CSIRO Land and Water and Environment Canada, with financial support from the Murray-Darling Basin Commission, Land and Water Australia (then Land and Water Resources Research and Development Corporation), and Environment Australia (Young *et al.*, 1999).



The MFAT assesses the impact/benefits of different flow scenarios on the condition of physical habitat for native fish, waterbirds and vegetation communities, and also assesses the growth of algal blooms. The MFAT makes these ecological assessments using daily river flows as the primary input data to a number of ecological models that are largely parameterized on the basis of expert knowledge. The MFAT enables an objective and repeatable assessment, and also allows the integration of these assessments across spatial scales ranging from a single locality, through river zones, and up to the entire river system. The results from the MFAT can then be used to facilitate an informed trade-off process between environmental and human flow requirements.

1.1 Content and purpose of this report

This document was produced as part of a contractual agreement between the Murray Darling Basin Commission, the CRC for Freshwater Ecology and CSIRO Land and Water. It was compiled and edited by Anthony Scott[1] and Susan Cuddy[2] based on materials prepared by Bill Young[2], Susan Cuddy, Anthony Scott and Bronwyn Rennie[1] for the MFAT Procedure Manual, January 2003, (superseded by this document) and documentation which accompanies the MFAT software.

Its purpose is to provide up-to-date information on the implementation of the ecological models in MFAT, how to parameterize them and how to use the analysis tools provided as part of MFAT. It contains updated information to that contained in Young et *al*. (1999) but does not replace it.

This documentation is based on MFAT v.1.4 released by CSIRO in August 2003.

1.2 Basic structure of the MFAT

The MFAT is a decision support system that can be used to assess the ecological impact/benefit of different flow scenarios at various localities along the River Murray River, both in-channel and on the surrounding floodplains and wetlands. For in-channel localities, the daily river flows are used directly to predict the changes in fish habitat condition and algal growth. For floodplain and wetland localities, a floodplain configuration is set up which uses the daily river flows to estimate the timing and quantity of water reaching each floodplain or wetland. These results are then used to predict the response from floodplain vegetation, wetland vegetation and waterbirds. After setting up appropriate weightings, the MFAT Explore Tool can be used to analyse the results and to integrate assessments within river zones, across river zones or across the entire river system. Figure 1.1 shows the basic framework of the MFAT.

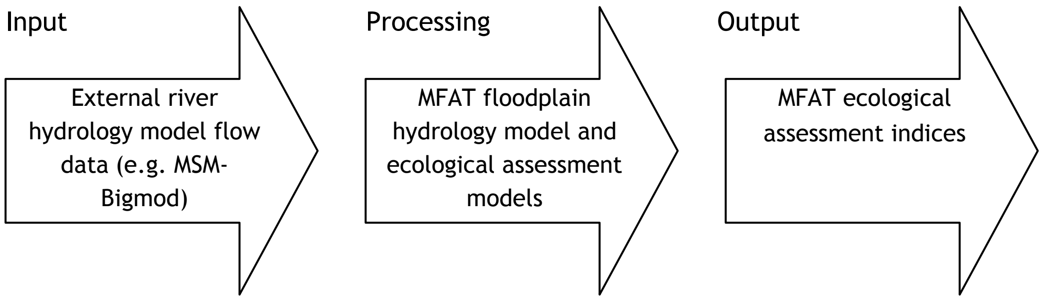


Figure 1.1 Basic framework of the MFAT

1.3 Software and hardware requirements

This section provides an overview of the system specifications of MFAT version 1.4.

Hardware

The MFAT runs on a PC platform under the MS Windows operating system using standard IBM PC clone hardware with at least a Pentium II processor. A minimum disk space of 200 MB is required although this is dependent on the number of flow scenarios and localities being assessed. As an example, a set of training databases (three flow scenarios and three floodplain configurations) required about 30 MB. A minimum of 128 MB RAM and a 800 x 600 pixel screen resolution are recommended.

[1] CRC for Freshwater Ecology
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Software

The MFAT has been developed using two different programming languages. This has come about because much of the MFAT is based on revisions to the EFDSS, for which total reprogramming could not be justified. The older components of the MFAT are written in MS Visual Basic and use the underlying RAISON™ software (developed by Environment Canada). These need some Visual Basic controls (*.VBX) and some components of the RAISON™ software to be installed. These are distributed with the software.

The rewritten (and new) components are coded in C# in the Microsoft .NET environment. The .NET framework is compatible with Windows operating systems '98, 2000, NT, and XP.

The software is distributed in a zip file. The contents of this file, and install instructions, are documented in Appendix A to this Report.

Supporting software

Microsoft .NET, Microsoft MDAC (data access components) and JET. These are available under free distributable licenses from Microsoft and are provided on the MFAT installation disk. Depending on the configuration of your computer, you may need to install none or all of these.

The original EFDSS was developed using tools from the RAISON™ for Windows Decision Support System (Lam *et al.*, 1994). A licensed copy of RAISON™ is also required to run some components of the read-write version of MFAT. RAISON™ licenses for MFAT can be obtained from the Murray-Darling Basin Commission under a special agreement with the National Water Research Institute, Environment Canada.

1.4 Databases

All MFAT data are stored in Microsoft Access™ Version 2.0 databases. Conventions for key, date and time series fields have been implemented. For example, most time series data are stored in binary long object (BLOB) fields to reduce storage requirements. These fields, which cannot be viewed within Access, can be displayed using the MFAT Explore tool. Databases and their tables are detailed in Section B.2 of this Report.

While CSIRO is responsible for the implementation of the models in MFAT, the databases were populated by the CRC FE and members of the Regional Evaluation Groups (REGs) established by the Murray Darling Basin Commission. Evidence, including references, supporting the data is contained in Evidence tables contained within the MFAT databases and in other documents produced as part of the *Living Murray Initiative*.

A conceptual diagram of MFAT databases and their linkages is available at Figure C.1.

1.5 Ecological assessments, localities and zones

Ecological assessments

The MFAT allows users to investigate different flow scenarios and their likely ecological consequences for river and floodplain environments. Ecological consequences are divided into two categories:

1. The habitat condition assessment category includes assessments for native fish habitat, floodplain vegetation habitat, aquatic wetland vegetation habitat, and waterbird habitat.
2. The nuisance assessment is an assessment of algal bloom occurrence.

Each of these single assessments (one ecological group assessed at one locality) can then be integrated using the MFAT Explore Tool.

Localities

The MFAT recognises six locality types:

- river sections
- weir pools
- billabongs/lagoons
- riverine lakes
- floodplains
- waterbird habitat complexes.

The first two are 'in-channel' locality types, the remainder are 'off-river' locality types.

Hydrology data is associated with localities, and simulation models can only be run at these localities. The in-river localities are described by hydrology data imported from an external hydrology simulation model, such as MSM-BigMod or IQQM. Off-river localities are described by hydrology data from the MFAT floodplain hydrology model. The hydrology data drives the assessment models at the different localities.

Details of locality types and a record of which assessments (or models) are run at each locality are stored in database tables which are defined during the MFAT setup process. Each run of an assessment model is for a single flow scenario at a single locality.

The ecological assessment models are associated with particular locality types (Table 1.1).

Table 1.1 Association between ecological models and locality types

Assessment Model	MFAT Locality Type	Hydrology Data
Native Fish Habitat Condition	'River Sections'	Each MFAT 'river section' locality is linked to a river node. Daily flow for each scenario and stage height data are provided for each river node by an external river hydrology model.
Floodplain Vegetation Habitat Condition	'Floodplains'	The Floodplain Hydrology Model is used to describe 'off-river' hydrology. The floodplain configuration is linked to a river node (flow file) to receive its initial inflow.
Wetland Vegetation Habitat Condition	'Riverine lakes' 'Billabongs/lagoons'	The MFAT Floodplain Hydrology Model is used to describe 'off-river' hydrology. The floodplain configuration is linked to a river node (flow file) to receive its initial inflow.
Waterbird Habitat Condition	'Waterbird habitat complex'	The MFAT Floodplain Hydrology Model is used to describe 'off-river' hydrology. The floodplain configuration is linked to a river node (flow file) to receive its initial inflow.
Algal Growth Model	'Weir Pools'	Each MFAT 'weir pool' locality is linked to a river node (flow file). Daily flow for each scenario and stage height data are provided for each river node by an external river hydrology model.

Zones

Localities are grouped into river zones to enable spatial integration. Zones have been mapped to the ten (10) River Murray reaches that have been defined for the *Living Murray Initiative*, and are shown in Figure 1.2.

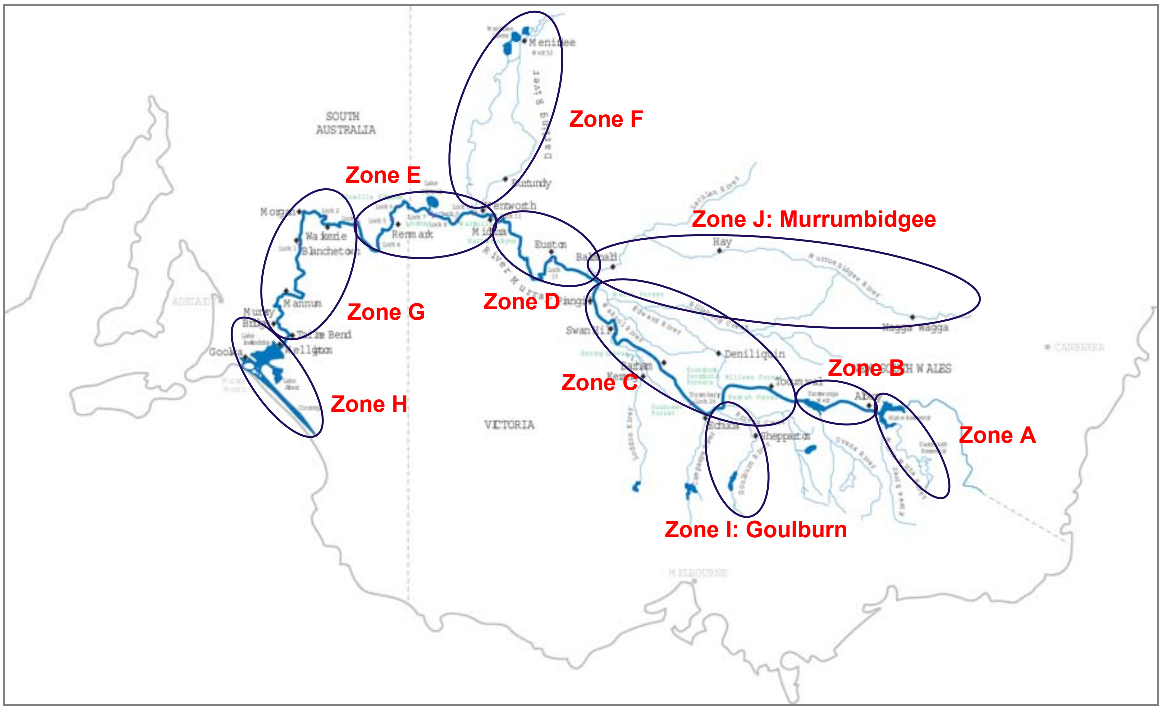


Figure 1.2 The ten zones along the River Murray System, being assessed using the MFAT as part of the *Living Murray Initiative*

1.6 Flow scenarios used in the MFAT

Within MFAT, a scenario is a set of daily flow records for selected river locations. There is no limit to the number of scenarios that can be loaded into the MFAT, except for any data storage constraints of the hardware being used. Clearly, large numbers of scenarios will increase processing and data access times. It is suggested that between 4 and 12 scenarios is sufficient to allow investigation of a wide range of alternative flow options. Extra scenarios can be loaded into the system at any time.

The MFAT recognises two special scenarios that are assumed to always be in the set of scenarios – the **'natural'** scenario, and the **'current'** scenario. The natural scenario is the flow conditions without flow regulation or diversion. This means no water management infrastructure – for example, dams – and no irrigation or other consumptive water use. Typically, it does not include natural land use conditions, as the data to allow calibration of a river hydrology model to pre-catchment disturbance conditions are seldom available. The current scenario is the flow conditions under the present level of development – land use, regulation and diversions.

Importantly, it is sensible for flow scenarios to be of the same length, eg 100 years of daily flow. This ensures consistency of prediction and comparison of alternate scenarios. These flow records can be provided by any river hydrology model, as long as the output is a file of daily flow values which can be imported into MFAT.

MSM-BigMOD and IQQM

For localities along the River Murray and lower Darling, the flow files for each scenario are provided by the MSM-BigMOD model, which has been developed by the MDBC. The model is complex and includes rainfall-runoff relationships, operating rules for storages, irrigation demands, water resource assessment and water accounting, and flow and salinity routing. MSM-BigMOD provides daily flows for a period of over 100 years. The flow series for each locality (or river flow node) are provided as a file which can be imported into the MFAT.

The IQQM model, developed by the NSW Department of Infrastructure, Planning and Natural Resources (previously Land and Water Conservation) (Podger *et al.*, 1994) provided the flow files for the Murrumbidgee River. A similar model provided flow files for the Goulburn River.

1.7 Read-only ('public') and read-write ('restricted') modes

The distributable version of MFAT is v1.4 which provides a read-only (public) mode for public distribution and a read-write (restricted) mode for licensed users. MFAT defaults to running in public mode.

To run MFAT v1.4 in read-write mode, a separate MFAT control program is required. This is available through the Commission, and its distribution is restricted by licence.

The only difference between the modes is that, in read-only mode, all databases are fully populated and the **Run** and **Save** buttons in the user interface are disabled. 'Fully populated databases' means that all models have been run and databases updated with run results. In public mode, you can view, but not alter, all data in the system. This includes input data, as well as run results. Disabled means that the buttons are either greyed out, or simply not displayed, depending on the context.

In the read-write mode, users can add/edit all input data, and run the assessments to populate the databases.

2 THE FLOODPLAIN HYDROLOGY MODEL

The MFAT includes a model for configuring and running simulations of floodplain hydrology. The model represents the floodplain system as a network of storages and pipes. The floodplain hydrology model provides a time series of daily volume for each storage, in the same way as the external river hydrology model provides a time series of daily flow for a river section. In fact, the floodplain hydrology model is driven by flow data provided by the external river hydrology model.

The model allows very simple or very complex configurations to be defined. The level of complexity should reflect both the actual complexity of the floodplain system, and also the extent of data available to accurately parameterise the model.

2.1 Elements of a floodplain configuration

A floodplain configuration is a set of storages which are linked by (conceptual) pipes. A simple example of a floodplain configuration is shown in Figure 2.1. The configuration must be defined before its storages and pipes can be created. A configuration must be linked to a ZONE to pick up the correct potential evapotranspiration (PET) data. This is provided in the Configuration 'Properties' dialog box.

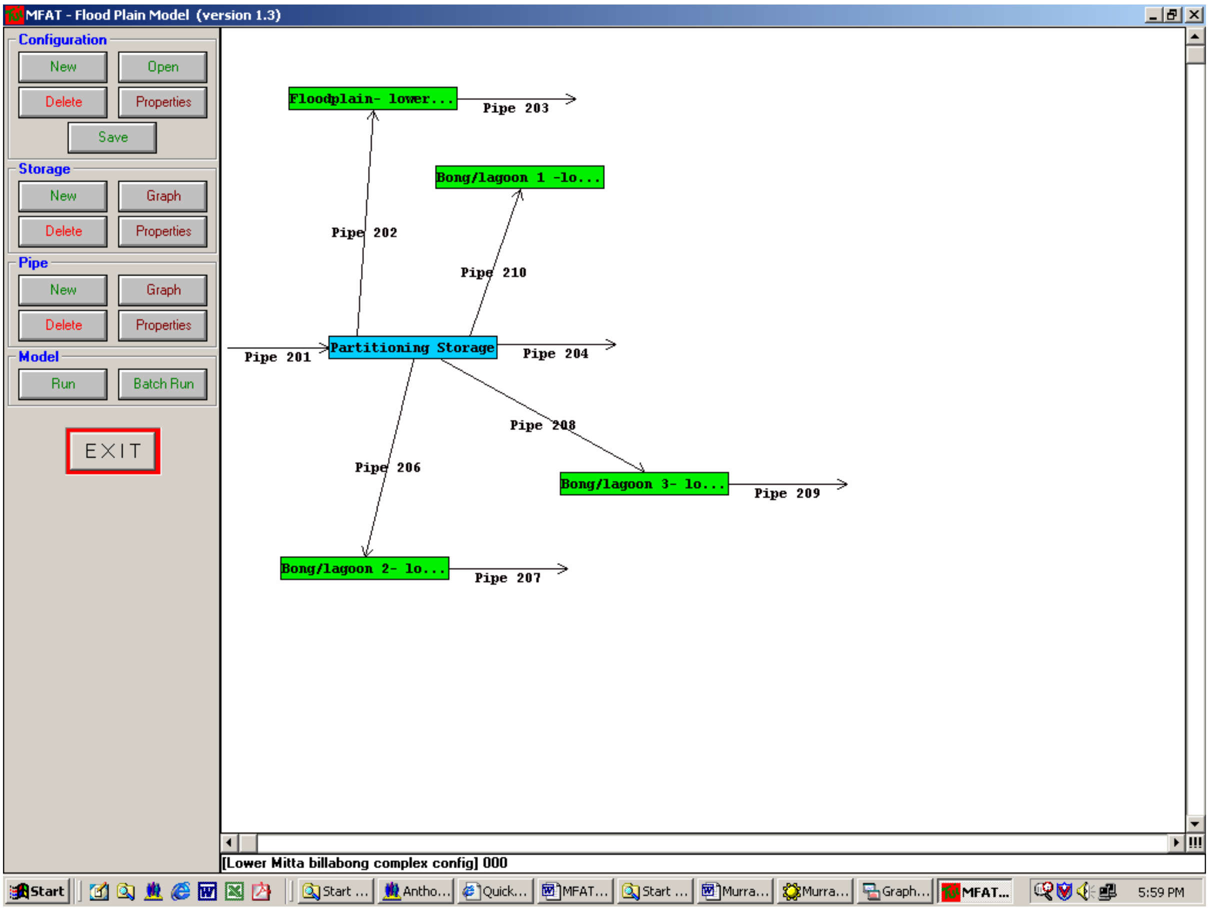


Figure 2.1 Floodplain hydrology model interface showing a simple floodplain configuration

Storages

Storages are elements on the floodplain which periodically receive water from the river. They are assigned one of the following types:

- <none> (used for special case of partitioning storage, ref below)
- floodplain
- billabong/lagoon
- riverine lake.

They are parameterised with

- maximum area
- maximum storage volume
- initial storage volume
- area-volume relationship
- (seepage) decay rate.

At each time step (*t*) the floodplain model calculates the volume (*V*) in a storage according to the water balance of Equation 2.1, in terms of the pipe inflows (*I*), pipe outflows (*O*), the evapo-transpiration rate (*ET*) across the inundated area (*A*), and the seepage rate (*k*).

$$V_t = \left(V_{t-1} + I_t - O_t - ET_t \times A_{t-1}\right) \times e^{kt} \qquad 2.1$$

Pipes

Storages are linked to the river and to each other via (conceptual) pipes. These pipes both feed water to a storage and drain water away from it.

Most pipes are parameterised with

- P_{min} – the volume in the source storage at which the pipe commences to flow
- P_{max} – the volume in the source storage that coupled with P_{min} defines the pipe capacity, vis capacity = P_{max} - P_{min}

A special class of pipe – a 'return pipe' – has no parameters and is described in the following section.

2.2 MFAT floodplain constructs

Storages and pipes can be parameterised to describe many types of behaviour that are observed on the floodplain. Special storage constructs have been developed for MFAT to describe

- partitioning flow from the river onto the floodplain
- fully shedding floodplains
- partially shedding floodplains
- multi-level shedding floodplains
- floodplain wetlands.

Details on how to use and parameterize these storages, and extra information on how to establish the volume area relationships and decay rate parameters, are below.

Pipe constructs have been developed to describe

- moving water between storages
- draining shedding floodplains (called ‘return’ pipes).

These are also described below.

River flow partitioning pipe and storage

If the river hydrology model does not provide flow to the floodplain, it is necessary to calculate this from channel flow. A simple construct for doing this is to set up a ‘partitioning’ storage to calculate the split between overbank flow reaching the floodplains and wetlands, and channel flow that continues down the main river channel.

To do this requires the construction of a storage with one input and multiple output pipes as follows:

1. a storage (of type <none>) of zero volume and zero decay rate
2. an input pipe to the storage whose flow is taken from a times series of river flow provided by a floodplain hydrology model
3. an output pipe from the storage that does not connect to another storage (notionally returns to the river) with a P_{min} of zero and a P_{max} that exceeds the highest flow ever experienced in that part of the river
4. any number of other output pipes that connect to other floodplain and wetland storages. Each pipe is set as follows
    - set the P_{min} to the ‘Commence to Flow’ (CTF) for the floodplain or wetland storage
    - set the P_{max} so that the peak flow reaching the storage is equal to P_{max} - P_{min}.

Fully shedding floodplains

For a floodplain whose water level rises and falls directly with the river water level (and has no lag and hence no ‘storage’ behaviour) use a ‘return pipe’ to drain all of yesterday’s water back to the river, so that today’s storage volume is equal to today’s inflow.

If the water level on the floodplain does not respond immediately to the water level in the river (and has a lag), but does eventually shed all water, a ‘standard’ pipe should be used for the output, with a P_{min} of zero. This allows all water to drain off the floodplain. The pipe capacity (P_{max} – P_{min}) will vary according to how rapidly the floodplain drains.

Partially shedding floodplains

Partially shedding floodplains (some water is retained on the floodplain after the flood recedes) have one or more output pipes but with P_{min} greater than zero, again with capacity reflecting rate of drainage. Complete drying in this case occurs through seepage (via the ‘decay rate’) or by evapotranspiration.

Multi-level shedding floodplains

To represent multi-level floodplains that occur as successive benches above the channel, link each successive higher level floodplain to the previous level floodplain using a single pipe. Higher level floodplain storages may have a 'return pipe' if they drain rapidly, and/or may have other 'drain' pipes that drain water more slowly.

Floodplain wetlands

Billabongs/lagoons, and riverine lakes are defined as 'floodplain wetlands' in MFAT, and may be represented by one or more storage elements.

Floodplain wetland storages may have one or more 'slow' (low capacity) drain pipes, but probably with P_{min} well above the empty storage level. The output pipe capacity is determined by P_{max} – P_{min}. These wetlands may empty by evaporation, or may also have a decay rate that increases the loss rate and represents drainage to groundwater.

Volume-Area Relationships

Each storage requires a volume-area relationship. This describes how the inundated area changes with storage volume. The volume-area relationship also defines the average depth of the storage (average depth = volume/area). The inundated area and the average depth are used in the waterbird habitat, floodplain vegetation habitat and wetland vegetation habitat condition models.

Volume-area curves should include some data points close to the origin to ensure that sensible depths are obtained for storages which are almost dry.

Volume-Area relationships will range from those for relatively steep 'U' cross-section billabongs which, as they drain or dry out, have a loss in volume with almost no loss in area (Figure 2.2), to wide, shallow riverine lakes formed in aeolian deflation basins, where initial drainage causes losses in both area and volume (Figure 2.3).

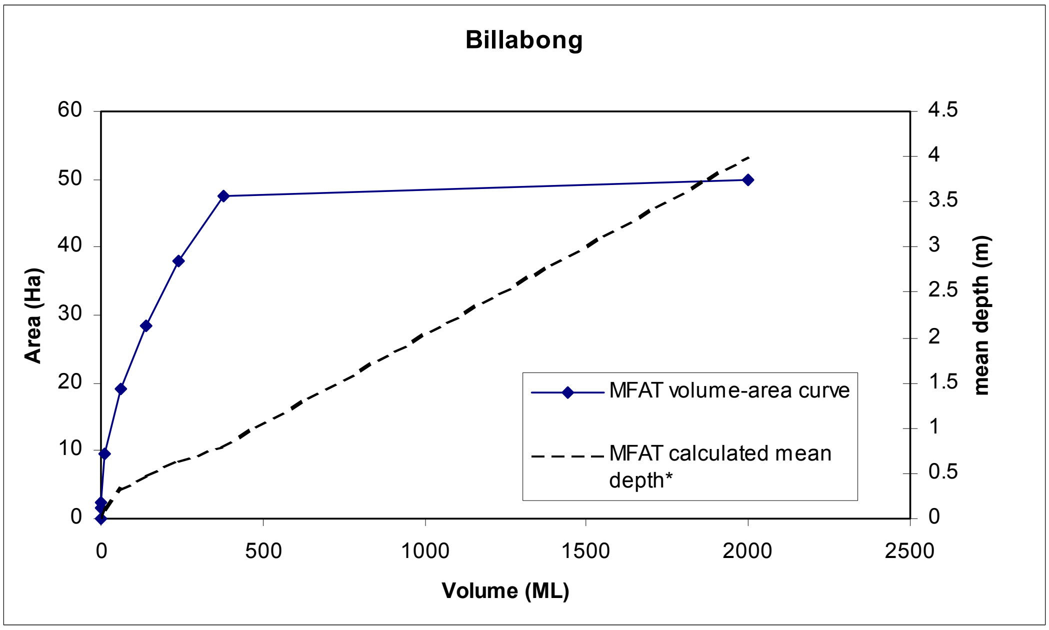


Figure 2.2 Suggested volume-area relationship for 'U' cross-section billabong

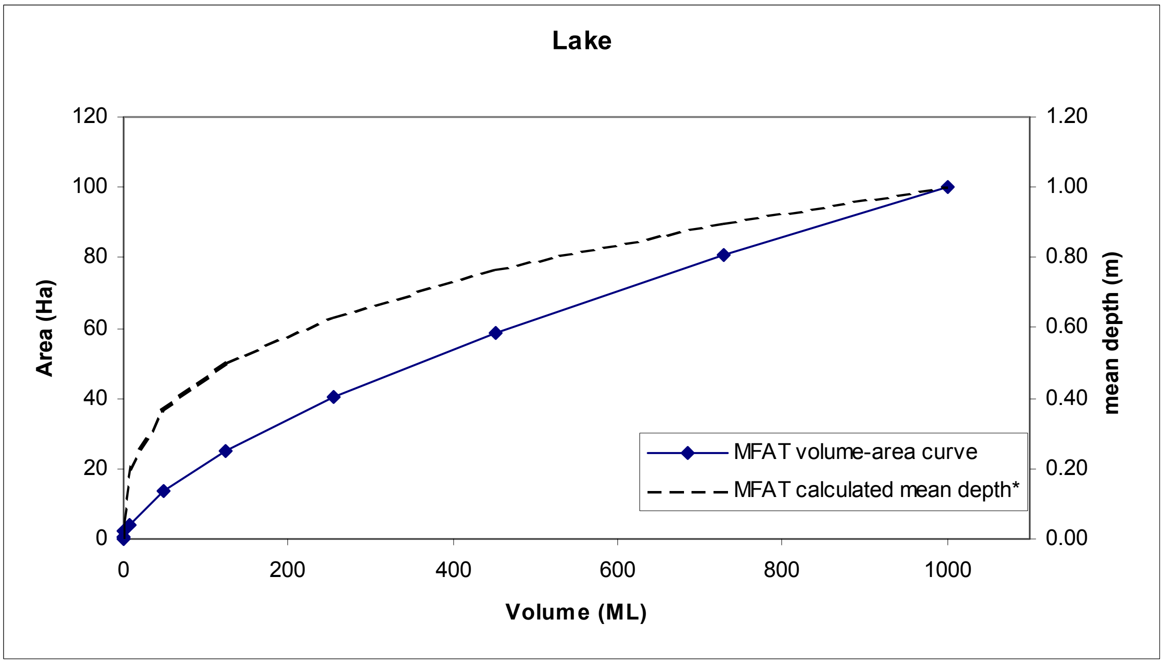


Figure 2.3 Suggested volume-area relationship shape for wide shallow riverine lake

More unusual storages include those where the **average** depth increases as they drain. This could occur for a waterhole with a deep central channel and a wide shallow margin. In this case the average depth will initially increase on draining, but then, once the central channel section begins to drain, the average depth will decrease.

Ideally, volume-area relationships would be established using cross-sectional survey information. However, knowledge of the typical cross-sectional shape is generally sufficient to represent the changes in inundated area with filling and draining.

Decay Rate

Storages are parameterised by an exponential decay rate (*k*). This is used to represent the rate at which water is lost to groundwater. Negative values are required to produce a loss (Equation 2.1). Realistic rates will depend on the soil type and the nature of underlying aquifers. Typically values are probably between –0.002 and –0.02, which represent loss rates of 0.2% and 2% respectively, per day.

Moving water between storages

For floodplain or wetland storages that are not fed by partitioning storages, their inflow pipe is set as follows;

- Set the P_{min} at the level in the supply storage at which the connected storage commences to fill with water. For example, if storage A, the 'supply' storage, (max volume 1000 ML) starts to flow into storage B, the connected storage, when it is 50% full, then set the P_{min} of the inflow pipe to storage B to 500ML.
- Set the P_{max} so that the peak flow reaching the new storage is equal to P_{max} - P_{min} . Note that P_{max} should be less than the maximum volume of the supply storage.

'Return pipes'

A return pipe is a special case of a pipe which is used to represent the rapid drainage of water from shedding floodplains directly back to the river – essentially a return pipe drains the storage in a single time step (day) once the river flow drops. Return pipes have no parameters.

For return pipes, the water balance of Equation 2.1 uses $O_t = V_{t-1}$ and hence the water balance for the source storage becomes simply that of Equation 2.2.

$$V_t = (I_t - ET_t \times A_{t-1}) \times e^{kt} \tag{2.2}$$

2.3 Procedural guide for setting up a floodplain configuration

The suggested procedure for setting up a floodplain configuration is outlined below.

Step 1 – draw a mud map
Produce a 'mud map' of the floodplain-wetland system, and identify floodplains (water shedding areas), wetlands (water holding areas), and connecting channels (water moving areas). Identify inflow and outflow pathways for these areas.

Step 2 – specify storages for assessment
Decide which storage elements of the system you wish to use to represent waterbird habitat, floodplain vegetation habitat or wetland vegetation habitat. (Consider elements with national or international significance, elements which are representative of the region, and elements which contain the best hydrological and ecological data).

Step 3 – specify other storages
Determine if there are any connecting storage elements within the system that must also be modelled to provide accurate hydrological inputs to the storage elements identified in (2).

Step 4 – record properties for each storage
Record the following data (and the references) for each storage element.

- (a) storage type (floodplain, riverine lake, billabong/lagoon)
- (b) number of connecting channels or pathways to river (a pathway might include overbank sheet flow). Each pathway will be modelled by a separate 'pipe'
- (c) maximum area in hectares of the storage element
- (d) maximum volume in ML (for a floodplain storage this will be defined by the largest flood recorded)
- (e) initial volume in ML. This will be 0 ML for a dry wetland and some other value for an already wet wetland. (This value is only used in the initial year of computation, and in most cases only affects the results for year 1.)
- (f) commence to flow (ML/day) in river when water flows along pathway (or pipe) into the storage element; and the river node which provides the in-stream flow data
- (g) maximum capacity of this pathway (ML)
- Repeat (f) and (g) for all inlet pathways to the storage element
- (h) volume in storage element when outflow commences to flow, and when it ceases to flow

- (i) return flow limit (water being moved back to the river system) in ML/day
- (j) volume-area relationship
- (k) average flood frequency and duration. Also record any other flooding data that might help calibrate the model.

Example configuration

Figure 2.4 is an example of a floodplain configuration. The configuration has a partitioning storage construct to determine overbank flow from the river, has two shedding floodplains at different levels, both with return pipes, and a riverine lake that receives water from the higher floodplain level.

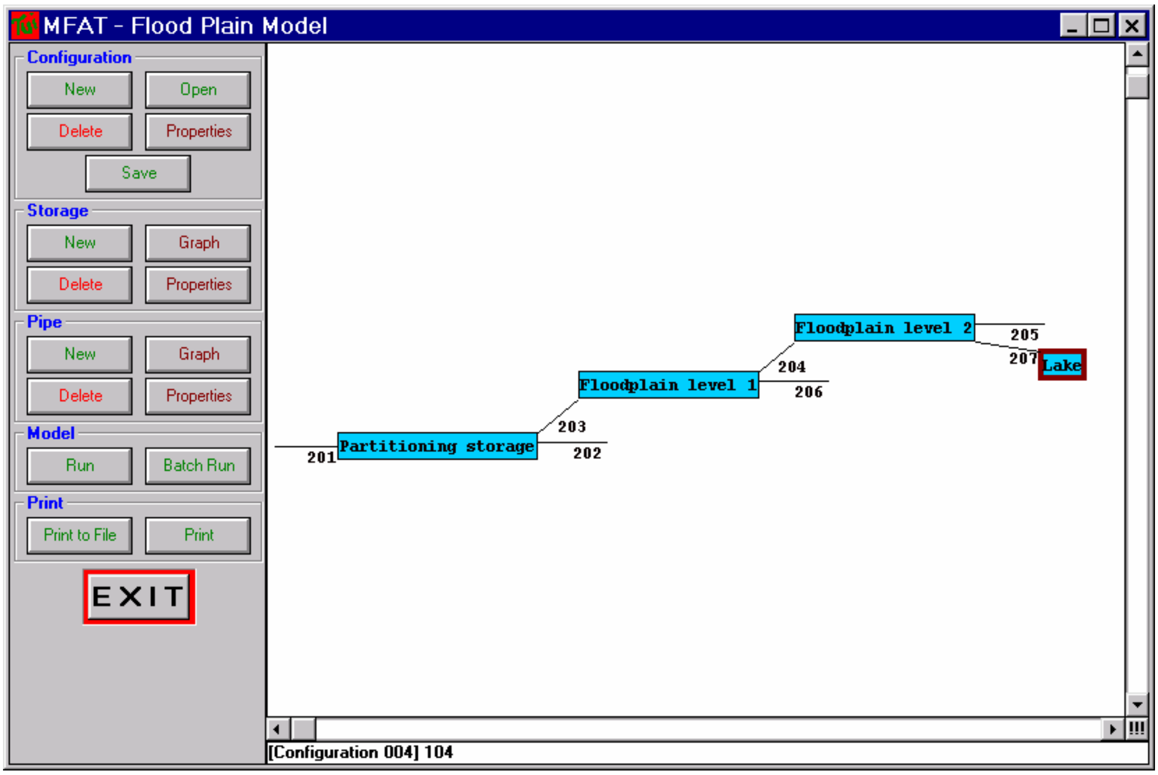


Figure 2.4 Example floodplain configuration

The lake is notionally contained within the higher floodplain, and receives water shortly after the floodplain is about 40% (by volume) inundated. The lake has no outlet pipe and loses water only by evapotranspiration (ET) and decay (groundwater seepage).

(The floodplain model only allows inflows from the left of the edit window. This means that connections must be drawn from the left, irrespective of which side of the river the system lies. For systems that have elements on both sides of the river, these two parts of the system would be drawn one above the other.)

Running the model[3]

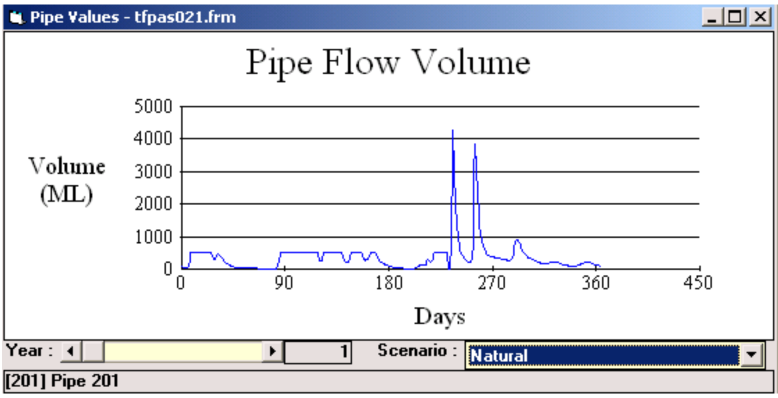
The command **Run** gives you the ability to run the configuration for one or all (flow) scenarios. The **Batch Run** button will run all scenarios for all configurations.

[3] Running the model is only available to those with MFAT read-write mode. For all others, the **Run** and **Batch Run** buttons are not available (they are disabled and greyed out).

Both **Run** and **Batch Run** take the daily inflow data (provided by the external river hydrology model) and then run it through the configurations of storages and pipes to produce daily time series of volumes in the pipes and storages.

Analysing results

The simulated volume time series for pipes and storages can be viewed by selecting **Pipe** Graph or **Storage** Graph.



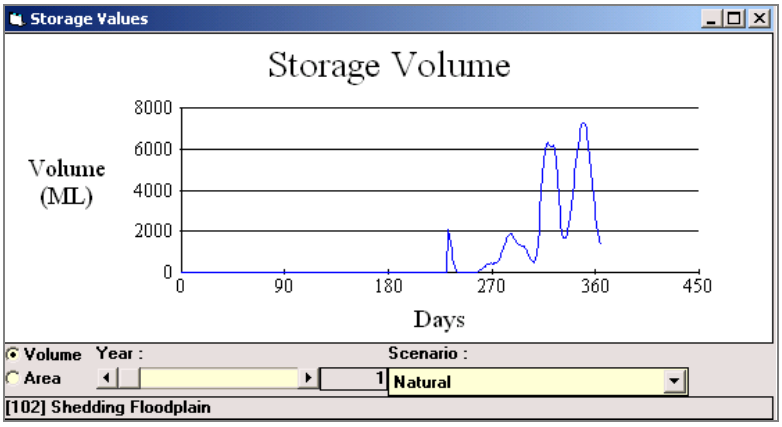


Figure 2.5 Examples of Pipe Flow Volume and Storage Volume graphs of daily volumes

The Storage Volume graph gives access to time series of the storage's daily volume and its daily area (via the radio buttons in the bottom left hand corner of the graph window). Time series for all scenarios can be visualized by selecting the scenario from the scenario list at the bottom of the graph window. (*Hint: Positioning the mouse over the right arrow of the year bar and double clicking will automatically move through the time series.*)

Calibration of the floodplain configurations

For each storage element, the simulated volume (and area) time series should be compared with field data and anecdotal knowledge of the flooding and drying patterns experienced by that storage. This will include a comparison of parameters such as;

- flood frequency
- flood duration
- flood magnitude (volume and area inundated)
- typical length of dry periods
- rate of drainage after flood recession

- rate of rise during floods.

Fine tuning of model response can be achieved by adjusting;

- inlet pipe properties (P_{min} and P_{max}) to adjust the rate of filling and the commence to flow
- outlet pipe properties (P_{min} and P_{max}) to adjust the rate of draining and the cease to flow volume
- decay rates (or groundwater seepage)
- maximum storage volumes and areas, and the area-volume graphs
- the number of input and output pipes connected to each storage.

3 MFAT ECOLOGICAL ASSESSMENT MODELS

The MFAT contains five ecological models. The first four models assess habitat condition under different flow scenarios for;

- native fish
- floodplain vegetation
- aquatic wetland vegetation
- waterbirds.

The fifth model is an assessment of Algal Growth (rather than habitat condition).

The first four ecological models rely on user-defined 'preference curves' to determine the output indices.

3.1 Preference Curves

X-axis

A preference curve has as its x axis (or input) a variable that is usually a function of the flow regime (a hydrologic or hydraulic variable) or a function of time (such as calendar month, or time duration – usually days or months). Some of the preference curves used in the models are functions of:

- daily water depth
- daily depth variability for the year
- flow percentile
- rate of depth increase
- duration of rate of depth increase
- rate of depth decrease
- duration of dry period between inundation
- percentage of total area inundated
- duration of inundation
- calendar months for spawning.

Most of the preference curves describe the response of a particular biotic group to environmental conditions. In addition to varying between groups these responses may also vary between localities. For example, not only may Golden perch have a different preferred season for spawning to Freshwater catfish, Golden perch in the lower Darling may have a different preferred season for spawning than Golden perch in the Murray near Yarrawonga.

Details of how to set individual preference curves will be considered in following sections, model by model.

Y-axis

A preference curve has as its y axis (or output) a non-dimensional index with a range from 0 to 1. Zero (0) is used to indicate intolerable habitat conditions, and one (1) is used to indicate 'ideal' habitat conditions. The index value of one (1) is not necessarily related to the 'natural' flow conditions, because it is recognised that while natural could be considered ecologically optimal for the entire system, the natural flow condition does not provide ideal habitat for all biota at all times.

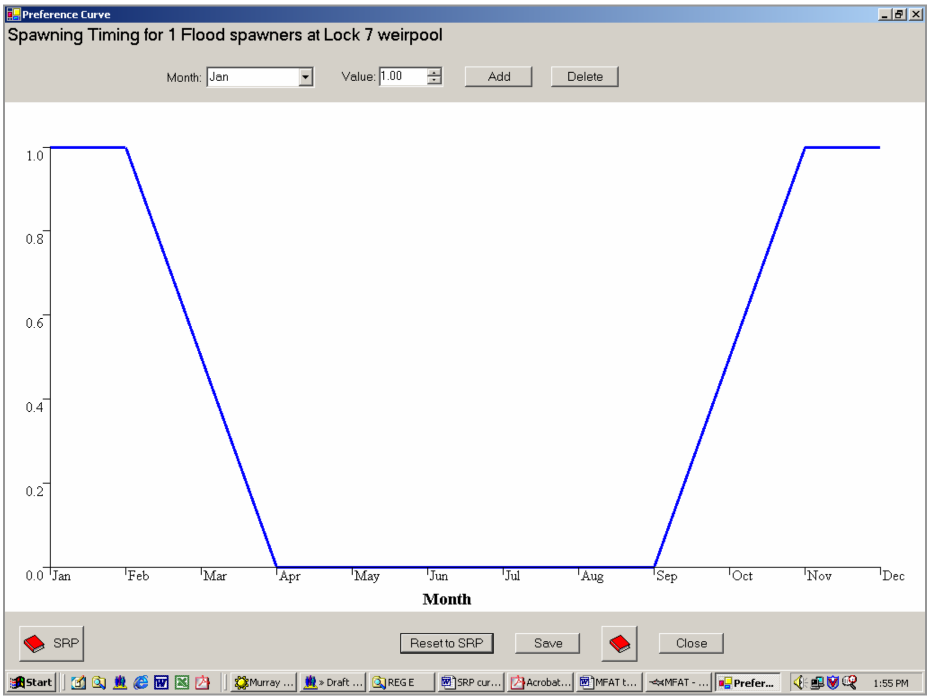


Figure 3.1 Preference curve for spawning timing of 'flood spawners'

3.2 Weights

MFAT uses weights within, between and across assessment models to indicate the relative importance of different aspects of the assessment.

At the assessment model level[4], weights are used to indicate the relative importance of

- life cycle stages
- each criterion within each stage.

Examples from the waterbird habitat assessment model are the relative importance of

- breeding habitat and foraging habitat to the overall waterbird habitat condition assessment
- flood duration, rate of fall, dry period and nesting vegetation to the breeding habitat condition assessment.

External to the assessment model,[5] weights indicate the relative importance of:

- different zones along the river
- assessment models for each zone
- localities within each zone, by assessment model
- groups and/or communities within each assessment at each locality.

[4] These weights are set and viewed within each assessment model.
[5] These weights are set and viewed using the MFAT Set up Weights tool.

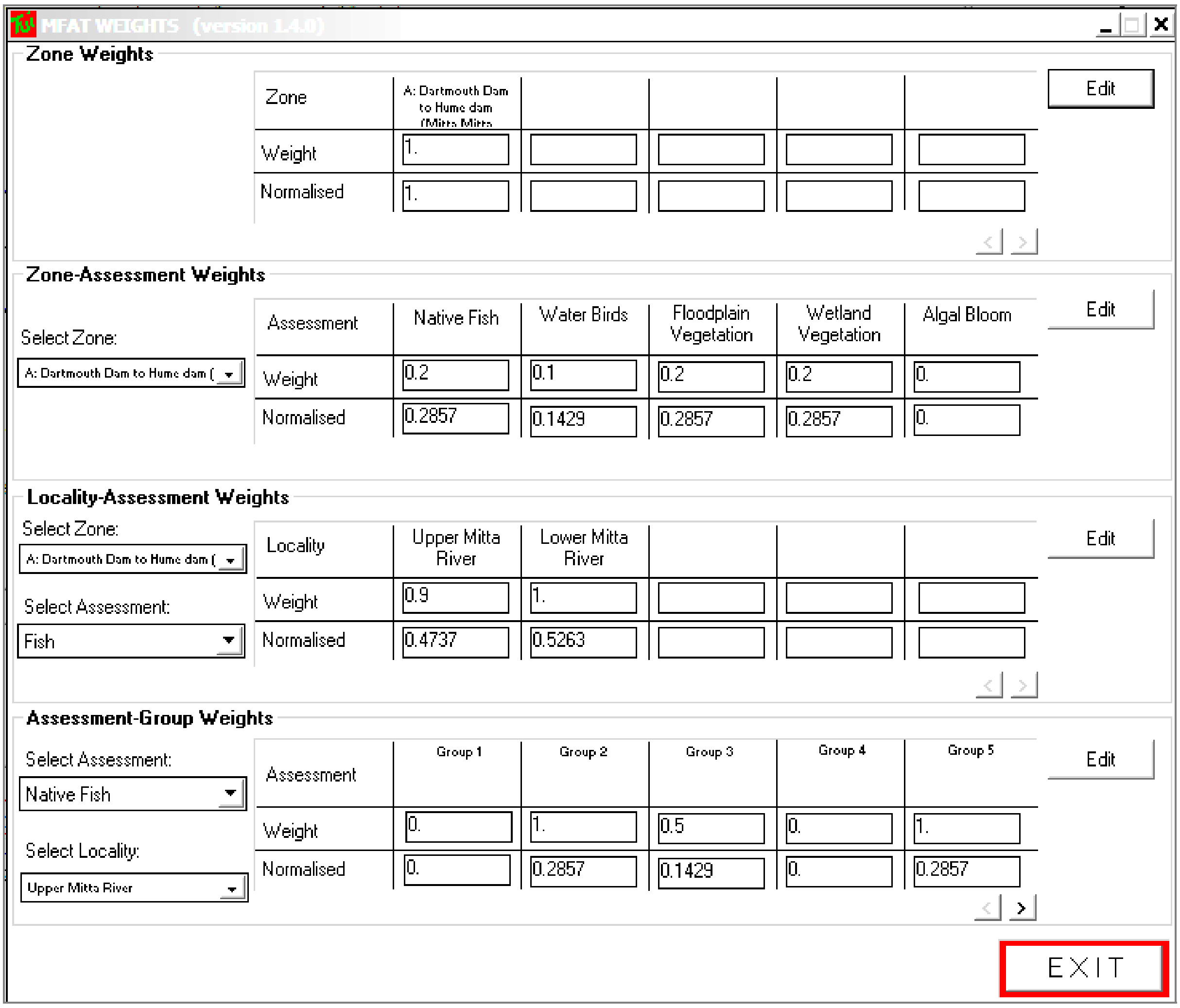


Figure 3.2 Weights window showing zone, zone-assessment, locality-assessment and assessment group weights for native fish at Upper Mitta river locality within Zone A. Note that these are not necessarily the weightings used in the *Living Murray Initiative* assessment.

The form shown in Figure 3.2 demonstrates how these weights are set.

Weights may reflect some or all of the following factors:

- amount or quality of information underpinning each component of the assessment
- relative extent (length or area) represented by the locality
- ecological importance of the species group or locality to the overall community structure
- conservation status of the particular group or locality
- icon status of the particular group or locality
- national or International significance of a particular group or locality
- indigenous interests
- local community or stakeholder group interests or values.

As with other data that is entered into MFAT, a facility is provided for users to record the 'evidence' or justification for the weights that are entered.

Setting weights

There is no prescription for setting weights. Indeed, they can all be set the same, ie each criterion, life cycle stage, assessment, locality and zone can have equal weighting. Weights are entered as integers. These values are normalised to being between 0 and 1 by MFAT and the entered values, and their normalised weights, are displayed.

Note that the overall assessments made by the MFAT Explore tool are integrated across all groups for a given assessment model. To take advantage of Explore to investigate statistics and indicators for a single group within an assessment model where several groups have been run, it is necessary to use weights of zero to 'turn off' the groups that are not of interest. This is only available to those with MFAT read-write mode.

3.3 Recording evidence

MFAT provides a simple mechanism (Figure 3.3) for recording the quality and source of ecological data and information that is used to assign preference curves and weightings. Four pieces of 'evidence' are recorded:

- author
- date of entry
- confidence level
- evidence and sources of information.

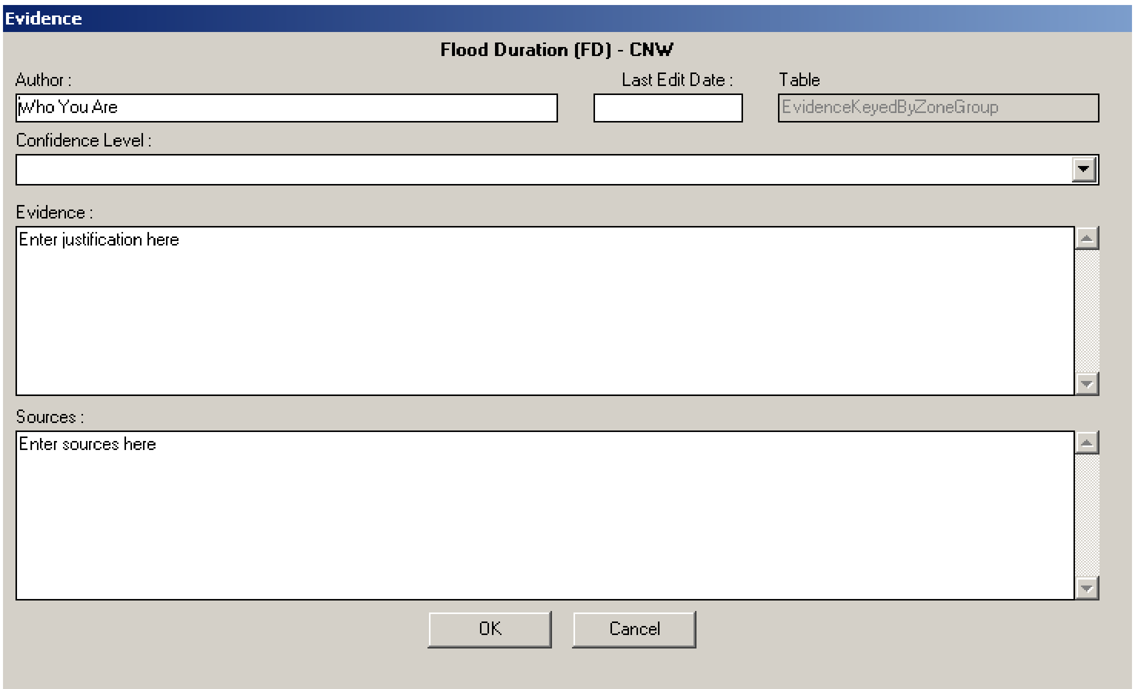


Figure 3.3 Form for recording evidence

A confidence level must be assigned to each piece of evidence. Three (3) levels are provided:

- (A) Expert judgement supported by data and consensus knowledge from published papers and reports

- (B) Expert judgement supported by unpublished data or knowledge that can be made available for public consideration
- (C) Expert judgement based on general scientific experience or anecdotal information.

The user who has entered the data will have made an appropriate selection from the Confidence Level list.

The ‘Evidence’ and ‘Sources’ boxes are MEMO fields which mean they have no limit on their length.

In the case of preference curves, two sets of evidence are recorded and available for viewing. One is associated with the default values provided by the Scientific Reference Panel (SRP), and are accessed via the SRP Evidence button. The other, to record evidence supporting any changes to the default values, is available via the standard Evidence button.

4 THE FLOODPLAIN VEGETATION HABITAT CONDITION MODEL

4.1 Model development

The MFAT floodplain vegetation habitat condition (FVHC) model is a refinement of the Vegetation Habitat Condition (VHC) model of the EFDSS (Young *et al*., 1999). The EFDSS VHC model was based primarily on information obtained via formal interviews with Leon Bren, Terry Hillman, Jane Roberts, Alistair Robertson, Geoff Sainty and Glen Walker in 1996. These conceptualisations are documented in Young *et al*. (1999), Roberts (2001) and diagrammatically in Appendix C, Figure C.2.

The refinements that led to the FVHC were primarily based on interviews with Jane Roberts and Terry Hillman in 2002-3, and were reviewed and endorsed for use in MFAT v1.4 by the Scientific Reference Panel of the *Living Murray Initiative.* Evidence supporting the MFAT input data is recorded in the Evidence tables in the FVEGHAB database for each zone. This evidence has been prepared by the CRC FE and regional evaluation groups.

4.2 Model description

The FVHC model enables simulation of the likely condition of floodplain vegetation habitat (primarily flow-related habitat) on the floodplains of the Murray River system under different river flow scenarios. The model is run for 'floodplains' for which the hydrology can reasonably be described by time series data of inundation volumes and inundation areas. Other input data are in the form of habitat preference curves that relate aspects of habitat condition to hydrologic, hydraulic or time variables.

Habitat condition is represented by a dimensionless 'unit' index that ranges from 0 (intolerable) to 1 (ideal). Ideal is not considered equivalent to natural, the latter usually being less than ideal for the long term average. Explicit consideration is made of adult and recruitment (specifically germination and seedling establishment) habitat preferences, with habitat condition indices calculated for each life stage.

Vegetation groups

Separate assessments are made for five (5) vegetation groups

- River red gum forest
- River red gum woodland
- Black box woodland
- Lignum shrubland
- Rats Tail Couch grassland/

4.3 Habitat condition indices

The annual floodplain vegetation habitat condition index (*FVHC*) is a weighted sum of an annual adult habitat condition index (*AHC*) and an annual recruitment habitat condition index (*RHC*) (equation 4.1). The annual values of *FVHC*, *AHC* and *RHC* are for a water year (July-June).

$$FVHC = x_1 AHC + x_2 RHC \qquad 4.1$$

where x_i are normalised weights that are defined for each vegetation group.

4.4 Adult Habitat Condition (AHC) indices

Adult habitat condition *(AHC)* is a function of unit indices for flood timing (*FT*), inundation duration (*FD*), annual drying period (*DP*) and flood memory (*FM*). A preliminary value of *AHC* (*AHC**) is calculated as a function of *FT*, *FD* and *DP* (equation 4.2).

$$AHC_* = \sqrt[3]{FT * FD * DP} \qquad 4.2$$

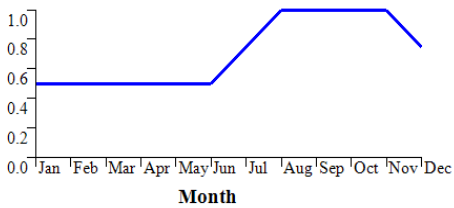
FM is partly a function of *AHC**. The final *AHC* is then a function of *FT*, *FD*, *DP* and *FM* (equation 4.3).

$$AHC = \sqrt[4]{FT * FD * DP * FM} \qquad 4.3$$

FT, *FD, DP* and *FM* are all determined by preference curves which are specific to vegetation group, but do not vary between localities. *FM* is also partly determined by 4 separate parameters, all of which are vegetation group specific.

Flood Timing (FT)

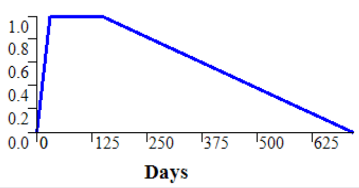
FT values are determined by a preference curve that indicates the relative preferability of the different calendar months for the timing of inundation of the floodplain (for the maintenance of adult vegetation). The preference curve is treated as a continuous function not a stepwise monthly function[6]. Daily *FT* values are therefore interpolated from the preference curve according to the position within a calendar month.



The annual value of *FT* for a water year is the median of the daily values over the duration (see ***Inundation Duration***) of the 'best flood event'. The 'best flood event' is the event that produces the highest value of *AHC**.

Inundation Duration (FD)

FD values are determined by a preference curve that indicates the preferred duration (in days) of floodplain inundation (for the maintenance of adult vegetation).



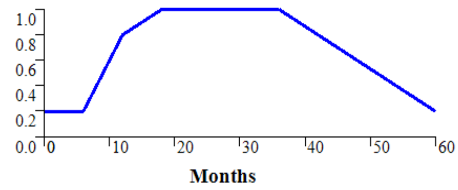
The annual value of *FD* for a water year is the single value from the preference curve for the 'best flood event', with the duration of the event being defined as the period for which the inundated area exceeds 50% of the total floodplain area.

Note: This definition of an inundation event means that, the volume-area relationships defined for the floodplain in the floodplain hydrology model will affect the FVHC model outputs.

Inter-flood Dry Period (DP)

DP values are determined by a preference curve that indicates the preferred duration (in months) of the dry period since the last flood.

[6] Sample graphs are provided with each preference curve as a visual aid to support the description of curve definition in this report. They are not necessarily endorsed by the authors or the Scientific Reference Panel.

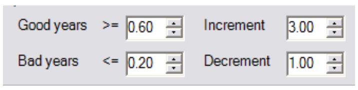


The preference curve is treated as a continuous function not a stepwise function. Daily *DP* values are therefore interpolated from the preference curve according to the duration of the drying period in days. For *DP* the dry period is defined as duration of the period for which the inundated area remained continuously less than 5% of the total floodplain area before the flood event being assessed.

The annual *DP* value for a water year is the single *DP* value for the 'best flood event'.

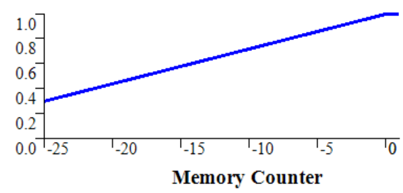
Flood Memory (FM)

FM is used to consider the importance to adult habitat condition of the inter-annual sequence of flood years and non-flood years. This allows simulation of a long term decline in habitat condition in response to overall flood frequency.



FM values are determined by a preference curve in terms of the value of a 'memory counter'. The memory counter is a running total of 'good' and 'bad' years for adult habitat condition. The counter value is determined by four parameters (set for each vegetation group) and the annual value of *AHC**. The first parameter ('Good years') sets the threshold (minimum) index value of *AHC** that defines a 'good' year, and the second parameter ('Increment') sets the amount by which the counter is incremented in a good year. The third parameter ('Bad years') sets the threshold (maximum) value of *AHC** that defines a 'bad' year, and the fourth parameter ('Decrement') sets the amount by which the counter is decremented in a bad year. In years that are neither good nor bad, the counter value does not change. The increments and decrements of the counter can be different, for example an increment of 3 and a decrement of 1 means that 3 'bad' years can be cancelled by one 'good' year.

It is suggested that the ratio of Increment:Decrement should reflect the natural flood frequency of the locality. For example, for a locality that was naturally flooded once in 4 years, set the increment to 4 and decrement to 1. You also need to define a 'good' year and a 'bad' year. This provides considerable flexibility to obtain sensible outputs. Default settings of 0.7 and 0.2 respectively have been set, but these might need to be adjusted by using the natural flow scenario to check what range of AHC* index scores are produced in flood years and non-flood years.



The range on the x-axis of the preference curve is related to the required long-term flood frequency for maintenance of a healthy population. The correct range is of course also a function of the decrement value. The memory counter is initialised at 0 at the beginning of a flow scenario, hence the *FM* preference curve should be set with *FM*=1 when the memory counter is 0. The memory counter is bounded above by 0 (the maximum value) and below by the minimum value used for the preference curve.

The flood memory index should remain high for flow scenarios which provide a sufficient flood frequency to maintain a healthy population, and should remain low for flow scenarios that provide insufficient floods. For example, with a decrement of 1, for a vegetation group requiring a flood at least once in 25 years, the range should be –25 to 0. The counter begins at zero (no history of bad years), and is restricted to stay within the range defined by the preference curve. Hence in the above example, the counter cannot go higher than 0 and will never drop below –25.

4.5 Recruitment Habitat Condition (RHC) indices

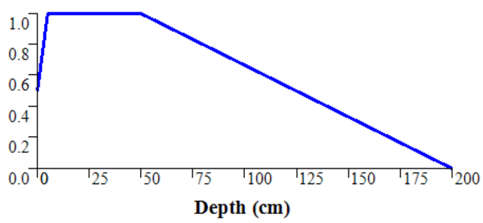
Recruitment habitat condition (RHC) is a function of unit indices for inundation depth (*ID*), inundation duration (*DD*), and germination timing (*GT*). The annual value for *RHC* depends upon *ID* and *DD* in the current year (*n*), and *GT* from the previous year (*n-1*) (equation 4.4).

$$RHC = \sqrt[3]{ID_n * DD_n * GT_{n-1}} \tag{4.4}$$

The *RHC* value for a water year is determined both from conditions in the previous year (for germination) and from conditions in the current year (for seedling establishment). For germination, only the timing of the required flow sequence is considered (*GT*). For seedling establishment, both the depth of inundation (*ID*) and the duration of inundation (*DD*) are considered.

Inundation Depth (ID)

ID values are determined by a preference curve that indicates the relative preference of different average inundation depths (in centimetres) for the establishment of one year old seedlings.

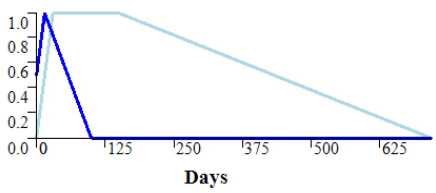


The input to this preference curve is average inundation depth (in cm) on a daily basis across the floodplain, as determined by the inundation volume and the volume-area relationship for the floodplain. These average floodplain depths may differ from the actual depths that individual plants at a specific location prefer or tolerate.

The annual *ID* value for a water year is the *ID* value for the 'best inundation event', this being the event with the highest value of the product of *ID* and *DD*. The *ID* value for an event is the median of the daily values within the event period. The period of the event is defined as the period for which the area inundated is continuously greater than 50% of the total floodplain area.

Inundation Duration (DD)

DD values are determined by a preference curve that indicates the relative preference of different durations of inundation (in days) for the establishment of one year old seedlings.



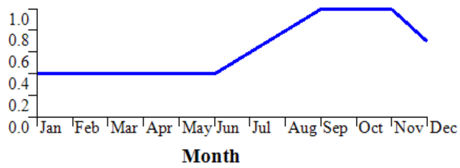
The duration of inundation is as defined for Inundation Depth (*ID*) (ie the period for which the area inundated is continuously greater than 50% of the total floodplain area), thus giving a single *DD* value for an inundation event[7].

The annual *DD* value for a water year is once again the *DD* value for the 'best inundation event' as defined above (see *Inundation Depth*).

Germination Timing (GT)

GT values are determined by a preference curve that indicates the preferred timing (in calendar months) of the flow sequence required for seed germination.

[7] The Inundation Duration (ID) sample graph shows two preference curves. This occurs when the user has changed the original curve distributed with the model, and saved those changes as a 'new' curve. The light blue curve displays the distributed curve, and the darker blue one that used for model runs.



The preference curve is treated as a continuous function not a stepwise monthly function. Daily *GT* values are therefore interpolated from the preference curve according to the position (day) in the calendar month.

The flow sequence required is a dry period following an inundation event. For this purpose a dry period is defined as a period for which the area inundated is less than 5% of the total floodplain area, and an inundation event is defined as a period for which the inundated area is greater than 50% of the total floodplain area. This flow sequence is required to occur within a 30 day period. That is, if an inundation event is found within the 30 days prior to the start of an identified dry period, the flow sequence criteria is fulfilled. The *GT* value for the flow sequence is the maximum of the daily values for the dry period following inundation, with the dry period limited to a maximum of 30 days for this purpose.

The annual *GT* value for a water year is the maximum of all identified event *GT* values.

4.6 Setting up the model

Step 1 – define locality
Firstly, the locality must be a storage in a floodplain hydrology model configuration, and be assigned the storage type 'floodplain'. The storage is assigned a name, the maximum inundation area and volume, as well as the volume-area relationship. This definition is done within the floodplain hydrology model.

Step 2 – specify vegetation groups
The next step is to specify which vegetation groups are to be assessed at this locality (several vegetation groups can be assessed at a single locality). Specifying multiple groups allows a comparison between vegetation groups that currently dominate the floodplain and other vegetation groups that used to dominate, or might thrive under altered conditions. In this way, an investigation of potential shifts in the vegetation community can be assessed.

Note of course that the model does not consider any interactions between these vegetation groups in terms of competition for resources (for example under and over-story species competing for light), grazing, or other confounding effects. If only one vegetation group at a single locality is to be assessed, the weightings for all other vegetation groups should be set to zero at that locality. If multiple vegetation groups at a single locality are assessed, consideration must be given to the most appropriate weightings to use for the overall assessment of floodplain health.

Step 3 – order of entry
Ensure all the necessary preference curves, weights and other required parameters are entered for each vegetation group specified for the locality. It is probably best to begin with the weights and then move to the adult habitat component of the model, then deal with the recruitment habitat component.

Step 4 – assign weights

For each vegetation group there is only one set of weights to be defined – those which determine the relative importance of adult habitat condition and recruitment habitat condition to the overall FVHC index. For the five vegetation groups listed above, default values are provided together with the evidence (or justification) of these values. These can be changed if there is reasonable evidence for different values. The evidence should be documented in the **Evidence form**.

Step 5 – define adult habitat condition preference curves

For the adult habitat component there are three 'standard' type preference curves (Inundation Timing (*IT*), Inundation Duration (*ID*) and Dry Period (*DP*)) that differ between vegetation groups but not between localities. Default curves are provided, but might need adjusting for some localities. The evidence for any changes should be provided in the **Evidence form**.

Step 5b – define the flood memory preference curve

The fourth preference curve for adult habitat condition – flood memory – is unusual and it is only used in this model. The preference curve shows the dependence of the flood memory index on a flood memory counter. Default settings for the memory counter and for the preference curve have been assigned, but might need to be adjusted. The steps are

1. set the counter Increment value for good years
2. set the counter Decrement value for bad years
3. set the threshold value of the initial AHC value - product of inundation timing (FT), inundation duration (FD), and dry period (DP) - that defines a good year, and
4. set the threshold value of the initial AHC value (product of FT, FD, DP) that defines a bad year
5. define the preference curve.

Step 6 – define recruitment habitat condition preference curves

For the recruitment habitat component there are three preference curves (germination timing, inundation depth and depth duration) that differ between vegetation groups but not between localities. Default curves are provided, but might need adjusting for some localities. The evidence for any changes should be provided in the 'evidence' windows.

Step 7 – run the model

The model is run using the controls on the left panel to select the vegetation group and locality. A batch run will run all groups and localities using the current settings. The index and sub-index outputs for the latest run can be viewed using the 'diagnostics' tab. Use the check boxes to select the indices to be viewed, either as annual or daily time series.

Step 8 – analyse results

The MFAT Explore tool provides various statistics and spell analyses on the model output, but only on the group-integrated FVHC index time series. Once again, if multiple vegetation groups are being assessed at one locality, the weightings for each vegetation group must be carefully specified.

5 THE WETLAND VEGETATION HABITAT CONDITION MODEL

5.1 Model development

The MFAT wetland vegetation habitat condition (WVHC) model is a refinement of the Vegetation Habitat Condition (VHC) model of the EFDSS (Young *et al*., 1999). The EFDSS VHC model was based primarily on information obtained via formal interviews with Leon Bren, Terry Hillman, Jane Roberts, Alistar Robertson, Geoff Sainty and Glen Walker in 1996. These conceptualisations are documented in Young *et al*. (1999), Roberts (2001) and diagrammatically in Figure C.3.

The refinements that led to the MFAT WVHC were primarily based on interviews with Jane Roberts and Terry Hillman in 2002-3, and were reviewed and endorsed for use in MFAT v1.4 by the Scientific Reference Panel of *the Living Murray Initiative.* Evidence supporting the MFAT input data is recorded in the Evidence tables in the WVEGHAB database for each river zone. This evidence has been prepared by the CRCFE and regional evaluation groups.

5.2 Model description

The WVHC model enables simulation of the likely condition of wetland vegetation habitat (primarily flow-related habitat) in the floodplain wetlands of the River Murray system under different river flow scenarios. The model can be run for ‘riverine lakes’ or ‘billabongs/lagoons’ for which the hydrology can reasonably be described by time series data of inundation volumes and inundation areas. Other input data are in the form of habitat preference curves that relate to aspects of habitat condition to hydrologic, hydraulic or time variables.

Habitat condition is represented by a dimensionless ‘unit’ index that ranges from 0 (intolerable) to 1 (ideal). Ideal is not considered equivalent to natural, the latter usually being less than ideal for the long term average. Explicit consideration is made of adult and recruitment habitat preferences, with habitat condition indices calculated for each life stage.

Vegetation groups

Two major wetland vegetation types are considered in the model: ‘edge plants’ and ‘open water plants’.

Separate assessments are made for four (4) edge plants

- Cumbungi (Typha) rushlands
- Phragmites australis rushlands
- Spiny mudgrass (Moira grass) grasslands
- Giant rush rushlands

and one (1) open water plant

- Ribbonweed (Vallisneria) herblands.

5.3 Habitat condition indices

The annual wetland vegetation habitat condition index (*WVHC*) is a weighted sum of an annual adult habitat condition index (*AHC*) and an annual recruitment habitat condition index (*RHC*) (equation 5.1). The annual values of *WVHC*, *AHC* and *RHC* are for a water year (July-June).

$$WVHC = x_1AHC + x_2RHC \qquad 5.1$$

where x_i are normalised weights.

5.4 Adult Habitat Condition (AHC) indices

AHC is a function of unit indices for inundation depth (*ID*), inundation timing (*FT*), depth duration (*PD*) and rate of depth change (*RD*) (equation 5.2).

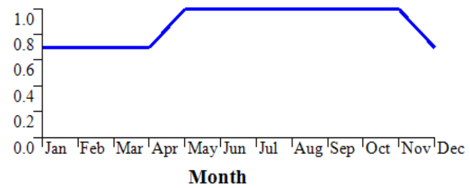
$$AHC = ID * \sqrt[3]{FT * PD * RD} \qquad 5.2$$

FT, *PD* and *RD* are all determined by preference curves which are specific to a vegetation group, but do not vary between localities. *ID* is determined by a 'restricted preference curve' – a square wave specified by upper and lower depth limits; these limits are specific to a vegetation group but do not vary between localities. *AHC* is assessed for one or more inundation events during the water year – an inundation event being any period during which the depth is within the range specified for *ID* (see *Inundation Depth* below).

The annual *AHC* value for a water year is the median of the event *AHC* values.

Inundation Timing (FT)

FT values are determined by a preference curve that indicates the relative preferability of the different calendar months for the timing of inundation of the wetland (for the maintenance of adult vegetation).

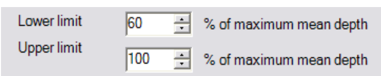


The preference curve is treated as a continuous function not a stepwise monthly function. Daily *FT* values are therefore interpolated from the preference curve according to the day within a calendar month.

The *FT* value for an inundation event is the median of the daily *FT* values within the event.

Inundation Depth (ID)

ID values are determined by a 'restricted preference curve' which has a square waveform and is specified by a lower limit and an upper limit.

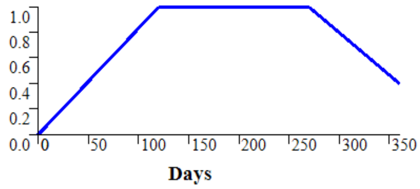


The lower limit is the minimum inundation depth that is suitable for maintaining adult plants of the particular vegetation group. The upper limit is the maximum inundation depth that is suitable for maintaining adult plants of the particular vegetation group. Both these inundation depth limits are specified as percentages of the maximum mean depth for the wetland. These average wetland depths may differ from the actual depths that individual plants at a specific location prefer or tolerate. For depths within the specified range, *ID*=1, and for depths outside the specified range, *ID*=0.

The annual value of *ID* for a water year is always 1 unless the depth is never within the specified range, in which case, *ID* and hence *AHC* are both zero. *ID* therefore specifies the inundation events for which event *AHC* values are determined based on *FT*, *DP* and *RD* index values for these events.

Depth Duration (PD)

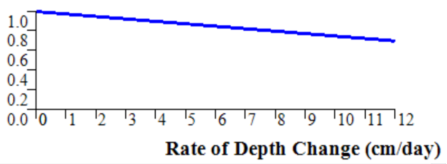
PD values are determined by a preference curve that indicates the relative preference of different durations (in days) of continual inundation for maintenance of adult wetland plants.



Continual inundation is defined as a period for which the depth does not go outside the inundation depth range specified for *ID*. This gives single values of *DP* for each inundation event, which contribute to event *AHC* values.

Rate of Depth Change (RD)

RD values are determined by a preference curve that indicates the relative preference of different rates of depth change (in centimetres per day) for the maintenance of adult wetland plants.



The value of *RD* for an inundation event is the median of the daily *RD* values within the event. The event *RD* value contributes to the event *AHC* value. *RD* allows consideration of stranding of edge plants (that prefer shallow water) by rapid decreases in water level.

5.5 Recruitment Habitat Condition (RHC) indices

RHC differs between edge plants and open water plants. For edge plants RHC_E is a function of unit indices for recruitment timing (*RT*), rate of depth decrease (*DC*), rate of depth increase (*DI*) and the 'inter-period' (*IP*) – the duration of the period between water level draw-down and rewetting (equation 5.3).

$$RHC_E = \sqrt[4]{RT * DC * DI * IP} \qquad 5.3$$

For open water plants RHC_O is a function of unit indices for recruitment timing (*RT*) and water depth (*WD*) (equation 5.4).

$$RHC_O = \sqrt{RT * WD} \qquad 5.4$$

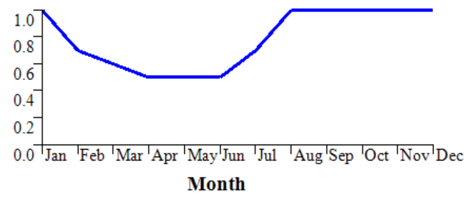
The sub-indices for RHC_E and RHC_O are all determined by preference curves which are specific to a vegetation group, but do not vary between localities.

Edge Plants (RHC_E)

For edge plants there is a sequence of flow conditions required for successful recruitment. The sequence begins with a water level draw-down that exposes the margins of the wetland. This exposure must be maintained for some period ('inter-period') before a rewetting phase induced by a water level rise. The annual RHC_E value for a water year is the maximum RHC_E value of all draw-down – rewetting sequences during the year. In assessing the rates of depth change for draw-down, inter-period and rewetting, any depth changes of less than 0.2 centimetres per day are ignored.

Recruitment Timing (RT) - edge plants

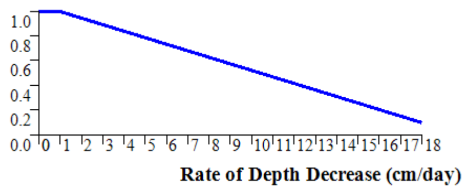
RT values are determined by a preference curve that indicates the preferred timing (in calendar months) of the draw-down – rewetting sequence required for recruitment of wetland plants.



The preference curve is treated as a continuous function, not a stepwise monthly function. Daily *RT* values are therefore interpolated from the preference curve according to the position within a calendar month. The *RT* value for a flow sequence is the maximum daily value for the period of the flow sequence. The period of the flow sequence begins on the day of a depth maxima (depths on prior and subsequent days are lower), and ends on the day of the next depth maxima. The first depth maxima in the water year determines the start date of the first flow sequence. The *RT* value for the flow sequence contributes to the RHC_E value for the flow sequence.

Rate of Depth Decrease (DC) - edge plants

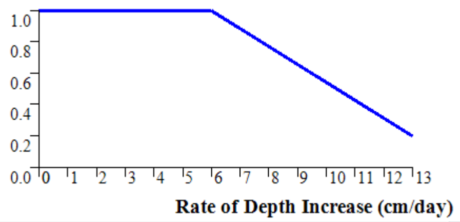
DC values are determined by a preference curve that indicates the relative preference of different rates of depth decrease (centimetres per day) for successful recruitment of wetland vegetation. This considers the suitability of the first phase of the necessary flow sequence.



The *DC* value for a flow sequence is the average of the daily values for the draw-down phase – that is from the first depth maxima to the first depth minima within the sequence. The *DC* value for a flow sequence contributes to the RHC_E value for the flow sequence.

Rate of Depth Increase (DI) - edge plants

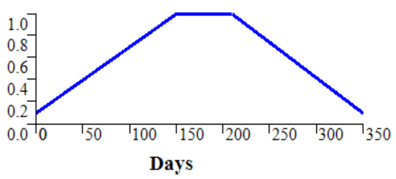
DI values are determined by a preference curve that indicates the relative preference of different rates of depth increase (centimetres per day) for successful recruitment of wetland vegetation. This considers the suitability of the final phase of the necessary flow sequence.



The *DI* value for a flow sequence is the average of the daily values for the rewetting phase – that is from the last depth minima to the final depth maxima within the sequence. The *DI* value for a flow sequence contributes to the RHC_E value for the flow sequence.

Inter-period (IP) - edge plants

IP values are determined by a preference curve that indicates the relative preference of different durations (days) of the period between draw-down and rewetting for successful recruitment of wetland vegetation. This considers the suitability of the middle phase of the necessary flow sequence.



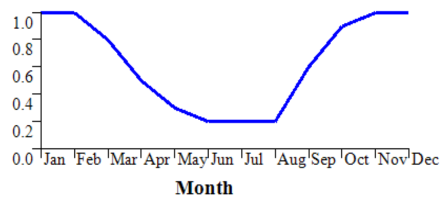
The *IP* value for a flow sequence is defined by the length of the entire draw-down period and any period without depth change. That is, the inter-period begins as soon as the water level first begins to fall – and thus exposes the extreme margins of the wetland. The inter-period ends when the water level begins to increase again - during an inflow event. The *IP* value for a flow sequence contributes to the RHC_E value for the flow sequence.

Open Water Plants (RHC_O)

For open water plants recruitment does not require a specific sequence of flow conditions. Recruitment depends only on the occurrence of suitable water depths at certain times of the year. The annual RHC_O for a water year is the median of the daily product of RT and WD values.

Recruitment Timing (RT) - open water plants

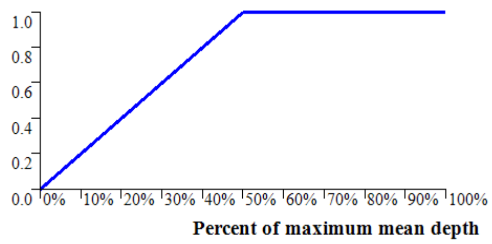
RT values are determined by a preference curve that indicates the relative preference for the different calendar months for the recruitment of wetland plants.



The preference curve is treated as a continuous function not a stepwise monthly function. Daily *RT* values are therefore interpolated from the preference curve according to the position within a calendar month. The annual *RT* value for a water year is the daily value that gives the median product of the daily *RT* and *WD* values.

Water Depth (WD) - open water plants

WD values are determined by a preference curve that indicates the relative preference of different water depths for the recruitment of wetland plants.



The water depth is specified as the 'percent of maximum mean depth in the wetland'. The annual *WD* value for a water year is the daily value that gives the median product of the daily *RT* and *WD* values.

5.6 Setting up the model

Step 1 - define locality

Firstly, the locality must be associated with a storage in a floodplain hydrology model configuration, and be assigned the storage type 'billabong/lagoon' or 'riverine lake'. The storage is assigned a name, the maximum inundation area and volume, as well as the volume-area relationship.

Step 2 - specify vegetation groups

The next step is to specify the vegetation groups to be assessed at this locality (several vegetation groups can be assessed at a single locality). Specifying multiple groups allows a comparison between vegetation groups that currently dominate the wetland and vegetation groups that used to dominate, or might thrive under altered conditions. In this way, an investigation of potential shifts in the vegetation community can be assessed.

Note of course, that the model does not consider any interactions between these vegetation groups in terms of competition for resources (such as emergent macrophytes shading submerged macrophytes), or confounding effects such as grazing by stock. If only one vegetation group at a single locality is to be assessed, the weightings for all other vegetation groups should be set to zero. If multiple vegetation groups at a single locality are assessed, consideration must be given to the most appropriate weightings to use for the overall assessment of wetland vegetation health.

Step 3 – order of entry

Ensure all the necessary preference curves, weights and other required parameters are entered for each vegetation group specified for the locality. It is probably best to begin with the weights and then move to the adult habitat component of the model, then deal with the recruitment habitat component.

Step 4 – assign weights

Only one set of weights is defined for each vegetation group — those which determine the relative importance of adult habitat condition and recruitment habitat condition to the overall WVHC index. For the wetland vegetation groups listed above, default values are provided together with the evidence (or justification) of these values. These can be changed if there is reasonable evidence for different values. The evidence should be documented in the **Evidence** forms.

Step 5 – define adult habitat condition preference curves

For the adult habitat component there are three 'standard' type preference curves (inundation timing, depth duration and rate of depth change) and one 'restricted' preference curve (inundation depth) that differ between vegetation groups but not between localities. Default curves are provided, but might need adjusting for some localities. The evidence for any changes should be provided in the **Evidence** forms.

Step 6 – define recruitment habitat condition preference curves

For the recruitment habitat component the number of preference curves depends on the vegetation type – open water or edge. For open water plants there are two preference curves (recruitment timing and water depth) and for edge plants there are four preference curves (recruitment timing, rate of depth increase, rate of depth increase and interperiod). Default curves are provided, but might need adjusting for some localities. The evidence for any changes should be provided in the **Evidence** forms.

Step 7 – run the model

The model is run using the controls on the left panel to select the vegetation group and locality. A batch run will run all groups and localities using the current settings. The index and sub-index outputs for the latest run can be viewed using the 'diagnostics' tab. Use the check boxes to select the indices to be viewed, either as annual or daily time series.

Step 8 – analyse results

The MFAT Explore tool provides various statistics and spell analyses on the model output, but only on the group-integrated WVHC index time series. Once again, note that if multiple vegetation groups are being assessed at one locality, the weightings for each vegetation group must be carefully specified.

6 WATERBIRD HABITAT CONDITION MODEL

6.1 Model development

The MFAT waterbird habitat condition (WHC) model is a refinement of the Waterbird Habitat Condition (WHC) model of the EFDSS (Young *et al*., 1999). The EFDSS WHC model was based primarily on information obtained via formal interviews with Bill Johnston, Richard Kingsford and Mike Maher in 1996, and from published literature. These conceptualisations are documented in Young *et al*. (1999), Scott (2001) and diagrammatically in Appendix C, Figure C.4.

The refinements that led to the MFAT WHC were primarily based on interviews with Richard Kingsford in 2002-3, and were reviewed and endorsed for use in MFAT v1.4 by the Scientific Reference Panel of *the Living Murray Initiative.* Evidence supporting the MFAT input data is recorded in the Evidence tables in the BIRDHAB database for each river zone. This evidence has been prepared by the CRCFE and regional evaluation groups.

6.2 Model description

The model enables simulation of the likely condition of waterbird habitat (primarily flow-related habitat) on the floodplains of the River Murray system under different river flow scenarios. It is constructed on the premise that waterbird habitat condition is most sensibly considered at a large spatial scale. Hence the model is run for ‘waterbird habitat complexes’ which are assemblages of floodplain elements within a lowland floodplain region, which in reality represent a wide range of different waterbird habitats. Such complexes are expected to be of the order of 10s to 100s of square kilometres. The model is also constructed on the premise that waterbird breeding occurs mainly on inundated floodplain elements, while waterbird foraging occurs mainly in the more permanent ‘wetland’ environments.

Thus a ‘waterbird habitat complex’ is described by a configuration of ‘floodplain elements’ (storages in the MFAT floodplain hydrology model) which contains at least one ‘floodplain’ and at least one of ‘riverine lake’ or ‘billabong/lagoon’. Only ‘floodplain’ elements are considered in the assessment of breeding habitat condition, and only ‘billabong/lagoon’ and ‘riverine lake’ elements in the assessment of foraging habitat condition.

The hydrology of waterbird habitat complexes for a scenario is described by time series data of inundation volumes and inundation areas for each floodplain element. The primary input data are simulated daily floodplain storage volumes and areas. Other input data are in the form of habitat preference curves that relate aspects of habitat condition to hydrologic, hydraulic or time variables, and qualitative descriptions of available nesting vegetation.

Habitat condition is represented by a dimensionless ‘unit’ index that ranges from 0 (intolerable) to 1 (ideal). Ideal is not considered equivalent to natural, the latter usually being less than ideal for the long term average. Explicit consideration is made of breeding and foraging habitat preferences, with habitat condition indices calculated for each aspect.

Waterbird groups

Separate assessments of breeding habitat condition are made for two (2) waterbird groups

- colonial nesting waterbirds - *includes ibis, egrets herons and spoonbills*
- waterfowl and grebes - *includes the flood dependent species such as grey teal, pink-eared duck, freckled duck, Australasian shoveler, great-crested grebe, hoary-headed grebe*

A single assessment of foraging habitat is made, as there are no major differences in habitat preferences between the two groups.

6.3 Habitat condition indices

The annual waterbird habitat condition index (*WHC*) is a weighted sum of an annual breeding (recruitment) habitat condition index (B*HC*) and an annual foraging habitat condition index (*FHC*) (equation 6.1). The annual values of *WHC*, B*HC* and *FHC* are for a water year (July-June).

$$WHC = x_1 BHC + x_2 FHC \qquad 6.1$$

where x_i are normalised weights.

6.4 Breeding Habitat Condition (BHC) indices

BHC is a function of the product of a unit index describing the extent or quantity of breeding habitat, and a term that describes the quality of the available breeding habitat (equation 6.2). The unit index for habitat extent or quantity is the percentage area inundated (AI_R) index. The inclusion of an index to describe quantity recognises that the largest waterbird breeding events always occur when there is a large extent of suitable habitat available, thus attracting many individuals from a wide region to a particular waterbird habitat complex.

The quality term in *BHC* is a weighted sum of unit indices for flood duration (*FD*), rate of water level fall (*RF*), duration of the dry period before flooding (*DP*) and extent of suitable nesting vegetation (*NV*) (equation 6.2).

$$BHC = \sqrt{AI_B * \left(x_3 * FD + x_4 * RF + x_5 * DP + x_6 * NV\right)} \qquad 6.2$$

where x_i are normalised weights.

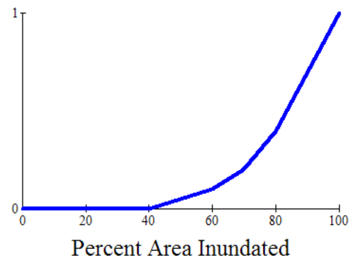
Note: The formula displayed on the MFAT user interface uses the term SQRT rather than the square root operator.

AI_B, *FD*, *RF* and *DP* are all determined by preference curves. Each waterbird group has its own set of preference curves. The preference curves for *AI* and for *DP* are also specific to each waterbird habitat complex, as they describe how the locality responds to inundation. In contrast, *RF* and *FD* relate to aspects of waterbird breeding physiology or behaviour. *NV* values are specific to both the waterbird habitat complex the waterbird group, and to a flow scenario.

The annual *BHC* value for a water year for an entire waterbird habitat complex is a weighted sum of the *BHC* values for each separate floodplain element for the water year. The individual floodplain element *BHC* values are weighted according to the corresponding total area of the floodplain element. The *BHC* value for an individual floodplain element for a water year is a function of the AI_B, *FD*, *RF*, *DP* values for the floodplain element for the water year.

Area Inundated (AI_B)

AI_B values are determined by a preference curve that describes the change in breeding success with changes in the area inundated.



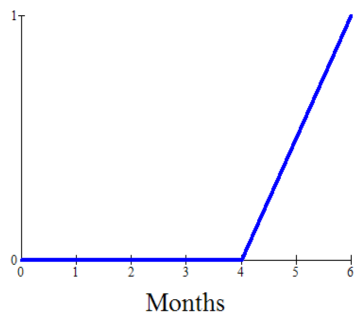
The area inundated is expressed as a percentage of the total area for the floodplain element. This preference curve is typically used to reflect the strongly non-linear increase in breeding success with increasing inundation extent. The annual AI_B value for a water year for a floodplain element is the maximum daily AI_B value for the year across all breeding events.

A breeding event is defined as any period for which the AI_R index value is continuously non-zero. Hence a breeding event begins when the percentage area inundated exceeds the threshold value on the AI_B preference curve. If the preference curve is always non-zero, or only goes to zero at the origin (0,0), then the floodplain element is deemed to be always in flood, which is equivalent to a continual breeding 'event'.

The maximum AI_B value for the water year defines the 'best breeding event' for the water year, and annual values for *FD, RF* and *DP* are those associated with this event.

Flood Duration (FD)

FD values are determined by a preference curve that describes the relative preference of different flood durations for waterbird breeding.

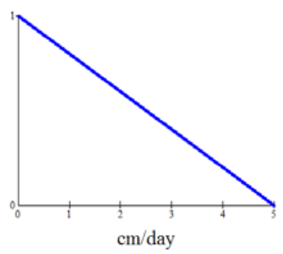


The preference curve is treated as a continuous function not a stepwise function according to the integer number months. Daily *FD* values are therefore interpolated from the preference curve according to the flood duration in days. Typically, a minimum flood duration is physiologically required to allow completion of the breeding sequence of laying, incubation and fledging. The flood duration is the duration of the breeding event as defined above (see ***Area Inundated***).

The annual *FD* value for a single floodplain element is the single *FD* value for the 'best breeding event' in the water year.

Rate of Fall (RF)

RF values are determined by a preference curve that describes the relative preference of different rates of water level fall (centimetres per day).



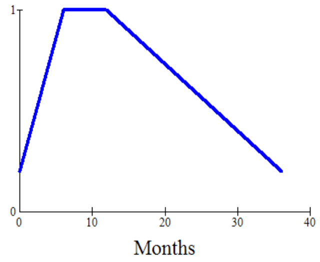
Typically there is a behavioural limit to the rates of water level drop that are tolerated before some waterbirds abandon the nest, thus causing a substantial reduction in, or total failure of, breeding.

The annual *RF* value for a single floodplain element is the maximum daily

RF value for the best breeding event in the water year.

Dry Period (DP)

DP values are determined by a preference curve that describes the relative preference of different durations of the pre-flood dry period.



The preference curve is treated as a continuous function not a stepwise function. Daily *DP* values are therefore interpolated from the preference curve according to the duration of the dry period in days. The pre-flood dry period is defined as the number of days for which the AI index is zero before the flood event. This gives a single *DP* value for a breeding event.

The annual *DP* value for a water year for a floodplain element is the *DP* value associated with the best breeding event for the water year.

Nesting Vegetation (NV)

NV is defined for each waterbird habitat complex – waterbird group – flow scenario combination. *NV* is restricted to one of three (3) constant values, each associated with one of the following qualitative descriptions of nesting vegetation availability: 'abundant', 'moderate', and 'sparse'. The index values associated with these descriptions may differ between the two waterbird groups.

6.5 Foraging Habitat Condition (FHC) indices

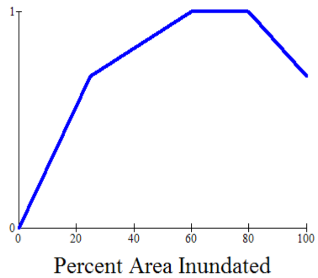
FHC is a function of unit indices for percentage area inundated (AI_F) and water depth variability (*WDV*) (equation 6.3).

$$FHC = \sqrt{AI_F * WDV} \qquad 6.3$$

The annual *FHC* value for a water year for an entire waterbird habitat complex is a weighted sum of the *FHC* values for individual wetland elements for the water year. The individual wetland element *FHC* values are weighted according to the corresponding total area of the wetland element. The *FHC* value for an individual wetland element for a water year is a function of the AI_F and *WDV* values for the wetland element for the water year.

Area Inundated (AI_F)

AI_F values are determined by a preference curve that describes the relative preference of different percentages of the total area inundated.

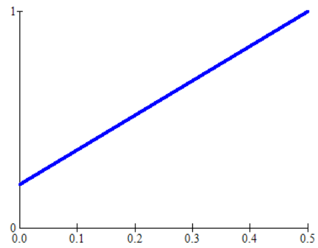


This is used as a surrogate for water depths, so the preference curve is an expression of the extent of the area of suitable foraging depths that occur at different percentages of inundated area. This is a reflection of the morphometry of individual wetlands (storages).

The annual AI_F value for a wetland element is the median of all the daily AI_F values.

Water Depth Variability (WDV)

WDV values are determined by a preference curve that describes the relative preference of different water depth variability values for waterbird foraging.



Annual Coefficient of Variation

The preference curve is defined in terms of the annual coefficient of variation of average wetland depth. The annual coefficient of variation is calculated for the water year based on all the daily values of average wetland depth.

The annual *WDV* value for a water year for a wetland element is the value from the preference curve corresponding to the annual CV of average wetland depth.

6.6 Setting up the model

Step 1 - define locality

The first step is to define and name the locality – which must be of type 'waterbird habitat complex'. This locality is then associated with one or more floodplain configurations. To model both breeding and foraging habitat the complex must contain at least one floodplain storage element and one of the various wetland storage element types.

Step 2 - associate locality / waterbird group(s)

Next, specify the waterbird groups relevant to the locality.

Step 3 - order of data entry

Ensure all the necessary preference curves, weights and other required parameters are entered for each waterbird group for the locality. It is probably best to begin with the weights and then move to the breeding habitat component of the model, then deal with the foraging habitat component.

Step 4 - assign weights

For each waterbird group there are two sets of weights to be defined – those which determine the relative importance of breeding habitat condition and foraging habitat condition to the overall WHC index, and those which determine the relative importance of the different sub-indices of the breeding habitat condition index. Default values are provided together with the evidence (or justification) of these values. These can be changed if there is reasonable evidence for different values. The evidence should be documented in the 'evidence' window.

Step 5 - define breeding habitat condition preference curves

For the breeding habitat component consideration must be given to the extent (or quantity) of available habitat and food resources, and the condition (or quality) of the available habitat.

The first is expressed using a preference curve on the percentage of total floodplain area that is inundated, and is locality specific. This curve is used to represent the strongly non-linear response of waterbird breeding to flooding. The largest floods lead to disproportionately large breeding events. Also, there is often a 'threshold' area that must be inundated before breeding will commence. If the area inundated is less than this threshold, little or no breeding might occur.

The condition (or quality) of breeding habitat is a weighted sum of four sub-indices – three 'standard' type index preference curves, and a constant index value. Two of the preference curves (flood duration and rate of fall) differ between groups but not between localities. The other preference curve (dry period) differs between localities and between groups. The fourth sub-index for the condition component of breeding habitat is a nesting vegetation index; this is a constant value indicating whether suitable nesting vegetation is 'abundant', 'moderate' or 'sparse'.

Default preference curves are provided, but might need adjusting for some localities. The evidence for any changes should be provided in the **Evidence** forms.

Step 6 – set foraging habitat condition preference curves

For the foraging habitat component there are two preference curves to define (which apply to both waterbird groups) - 'area inundated' and 'depth variability' These preference curves can vary between complexes. If you have more than one 'wetland' element in your complex, and they are of very different morphometries you will need to be extra careful to ensure a sensible result. Remember of course, that the indices are combined across wetlands by weighting on maximum area – hence try to ensure the preference curves are biased towards what is appropriate for the largest wetlands.

Default curves are provided, but might need adjusting for some localities. The evidence for any changes should be provided in the Evidence forms.

Step 7 – run the model

The model is run using the controls on the top panel to select the group, locality and scenario. A batch run will run all groups and localities, for all scenarios, using the current settings. The index and sub-index outputs for the latest run can be viewed using the **Graph** button.

Step 8 – analyse results

The MFAT Explore tool provides various statistics and spell analyses on the model output, but only on the group-integrated WHC index time series.

7 NATIVE FISH HABITAT CONDITION MODEL

7.1 Model development

The MFAT native fish habitat condition (NFHC) model is a refinement of the Native Fish Habitat Condition (NFHC) model of the EFDSS (Young *et al*., 1999). The EFDSS NFHC model was based primarily on information obtained via formal interviews with Angela Arthington, Peter Gehrke, Paul Humphries, John Koehn, Brian Lawrence, Brad Pusey in 1996, and also on published literature. These conceptualisations are documented in Young *et al*. (1999), Schiller and Harris (2001) and diagrammatically in Appendix C, Figure C.5.

The refinements that led to the MFAT NFHC were primarily based on interviews with Alison King, Angela Arthington, Ben Gawne, John Koehn, Shaun Meredith and Paul Humphries in 2002-3, and were reviewed and endorsed for use in MFAT v1.4 by the Scientific Reference Panel of *the Living Murray Initiative.* Evidence supporting the input data is recorded in the Evidence tables in the FISHHAB database for each river zone. This evidence has been prepared by the CRCFE and regional evaluation groups.

7.2 Model description

The NFHC model enables simulation of the likely condition of native fish habitat (primarily flow-related habitat) in the River Murray system under different river flow scenarios. The model is run for 'river sections' for which the hydrology can reasonably be described by time series data from a single location. The primary input data are simulated daily river flow volumes. Other input data include:

- a stage-discharge relationship,
- several habitat preference curves that relate aspects of habitat condition to hydrologic or hydraulic variables,
- qualitative time-invariant descriptions of other aspects of habitat such as woody debris, thermal pollution, riparian condition, channel condition.

Habitat condition is represented by a dimensionless 'unit' index that ranges from 0 (intolerable) to 1 (ideal). Ideal is not considered equivalent to natural, the latter usually being less than ideal for the long term average. Explicit consideration is made of adult, spawning, and larval-juvenile habitat preferences, with habitat condition indices calculated for each life stage. Separate assessments are made either for individual species, or for groups of species with similar habitat preferences, with species found in more than one habitat type appearing in more than one group.

Native fish groups

Separate assessments of habitat condition are made for seven (7) groupings of native fish

1	Flood spawners	Golden perch, Silver perch (Spawn and recruit following flow rises. Major spawning occurs during periods of floodplain inundation.)
2	Macquarie perch	(Require clean gravel substrate. Floodplain inundation not required, but spawning probably enhanced by rising flows.)

3	Wetland specialists	Australian smelt, Bony herring, Carp gudgeons, Southern pygmy perch, Hardyheads, *Galaxias rostratus*. (Spawn and recruit in floodplain wetlands (and lakes, anabranches and billabongs) during in-channel flows.)
4	Freshwater catfish	(Spawn in coarse sediment beds (usually sand or gravel) during any flow conditions.)
5	Main channel generalists	Australian smelt, Bony herring, Flathead gudgeons. (Spawn and recruit in high or low flow in the main channel.)
6	Main channel specialists	Murray Cod, Trout cod, River blackfish, Two-spined blackfish. (Spawn and recruit under high or low flow in the main channel. Woody debris important habitat attribute.)
7	Low-flow specialists	Crimson-spotted rainbow fish, Carp gudgeons. (Only spawn and recruit during low flow (channel or floodplain habitats).

7.3 Habitat condition indices

The annual native fish habitat condition index (*FHC*) is a weighted sum of an annual adult habitat condition index (*AHC*) and an annual recruitment habitat condition index (*RHC*) (equation 7.1).

$$FHC = x_1 AHC + x_2 RHC \qquad 7.1$$

where x_i are normalised weights.

7.4 Adult Habitat Condition (AHC) indices

AHC is a weighted sum of unit indices for woody debris (*WD*), fish passage (*FP*), water temperature (*WT*), channel condition (*CC*), and maintenance flow (*MF*) (equation 7.2).

$$AHC = x_3 WD + x_4 FP + x_5 WT + x_6 CC + x_7 MF \qquad 7.2$$

where x_i are normalised weights. *WD* and *WT* are locality specific but not group specific. *CC* is locality specific, and can vary between Group 4 and the other six groups. *FP*, *MF* and the weights x_1 to x_7 are group and locality specific. All AHC indices are also scenario specific – that is, they can take different values for different flow scenarios.

Woody Debris (WD)

A single value is used to describe the condition of woody debris at a locality for each scenario. This value can take one of five (5) values (in the range 0.0 to 1.0) which are matched to qualitative descriptions (Table 7.1). The values associated with the descriptions can be changed by the user, but the textual descriptions cannot.

Table 7.1 Woody Debris (WD) classes with default index values

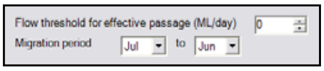
Class	Default value
No woody debris - fully desnagged	*0.0*
Few woody debris - major desnagging	*0.2*
Moderate level of woody debris - moderate desnagging	*0.4*
Numerous woody debris - minor desnagging	*0.7*
Woody debris at natural levels - no desnagging	*1.0*

Fish Passage (FP)

FP varies year-by-year according to scenario flow conditions, and describes the degree to which fish passage through the river sections is provided during the water year. However, in each year *FP* takes one of only five (5) constant values (Table 7.2). These values are associated with qualitative descriptions of the degree of fish passage within the river section locality for the flows within a water year (ie fish passage is defined for each scenario, locality, fish group combination). The values associated with these classes can be changed by the user, but the textual descriptions cannot.

Table 7.2 Fish Passage (FP) classes with default index values

Class	Default value
Flows never provided effective fish passage past the worst barrier in this river section during this year (ie flow < 'threshold' for entire year)	*0.0*
Flows provided effective fish passage past the worst barrier in this river section in this year, but not during target period	*0.2*
Flows provided effective fish passage past the worst barrier in this river section in this year, during target period, but for < 10 days	*0.4*
Flows provided effective fish passage past the worst barrier in this river section for > 10 days during target period this year	*0.7*
There are no barriers to fish passage in this river section	*1.0*



There are two user-defined values that are used to determine which class (and hence *FP* value) is appropriate for each year. These values are a threshold flow value for effective passage, and a migration period during which passage is preferably provided. The migration period is specified by a start month and an end month. The threshold flow values and the migration period are both locality and group specific.

Water Temperature (WT)

A single value is used to describe the degree of thermal pollution at a locality for each scenario. This value can take one of four (4) values (in the range 0.0 to 1.0) which are matched to qualitative descriptions (Table 7.3). The values associated with the descriptions can be changed by the user, but the textual descriptions cannot.

Table 7.3 Water Temperature (WT) classes with default index values

Class	Default value
High thermal pollution due to upstream dam	*0.0*
Moderate thermal pollution due to upstream dam	*0.4*
Minor thermal pollution due to upstream dam	*0.7*
No thermal pollution - natural thermal regime	*1.0*

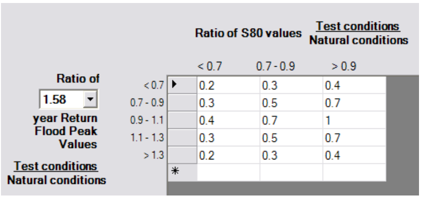
Channel Condition (CC)

A single value is used to describe the condition of the channel bed and banks for a locality. The value varies between scenarios according to flood magnitudes and flow variability.

An initial *CC* value is selected from a look-up table (Table 7.4) with three columns – reflecting different ranges of relative change in flow variability between the scenario of interest ('test') and the natural flow scenario ('reference'), and five rows – reflecting different ranges of relative change in flood magnitude between the scenario of interest ('test') and the natural flow scenario ('reference').

Table 7.4 Look-up table of Channel Condition (CC) default index values

	Ratio of S80 values for test condition/natural conditions		
Ratio of 1.58 year return flood peak values test condition/natural condition	*<0.7*	*0.7-0.9*	*>0.9*
<0.7	*0.2*	*0.3*	*0.4*
0.7-0.9	*0.3*	*0.5*	*0.7*
0.9-1.1	*0.4*	*0.7*	*1.0*
1.1-1.3	*0.3*	*0.5*	*0.7*
>1.3	*0.2*	*0.3*	*0.4*



The initial values in the look-up table can be changed by the user, and a choice of flood recurrence intervals on which to base the change in flood magnitude is provided (a default of 1.58 is provided). There are then four reduction factors (Table 7.5) that can be applied to the initial *CC* value.

Table 7.5 Channel Condition (CC) index reduction factors and default values

Channel straightened	*-0.2*
Bank erosion	*-0.2*
Inchannel sedimentation	*-0.2*
Absence of Macrophyte beds (for Group 4 – catfish))	*-0.2*

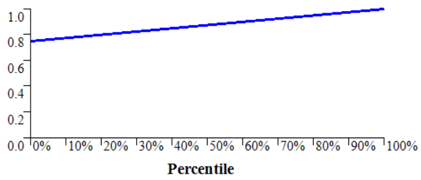
The reduction factors to use at a locality are selected by the user. One of the reduction factors (absence of macrophyte beds) is only ever used in determining *CC* values for fish group 4. The other three reductions factors apply to all groups. The values associated with each reduction factor can be changed by the user.

Maintenance Flow (MF)

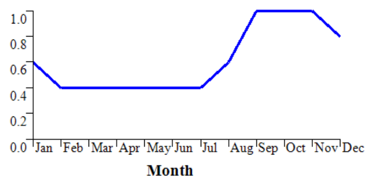
MF varies year by year according to scenario flow condition, and describes the degree to which any required adult habitat maintenance flow has been provided.

MF is specifically intended for Group 3 – the wetland specialists – that have no particular flow-related spawning requirements, but do require their wetland habitat maintained by flows at some times of the year. *MF* is however, group specific and different habitat maintenance flows can be specified for each group. These may include flows that flush biofilms or otherwise scour the bed to improve food supply, or improve the diversity of habitat within the channel. *MF* is defined in terms of the product of two sub-indices – a flow percentile (adult) (FP_A) index and a flow timing (FT) index (equation 7.3), both of which are defined by preference curves.

$$MF = \sqrt{FP_A * FT} \qquad 7.3$$



The flow percentile (adult) (FP_A) preference curve indicates the range of flows (in terms of daily flow percentiles from the natural flow regime) that are suitable as maintenance flows for the particular group.



The flow timing (FT) preference curve indicates the differing preferences for the timing (calendar months) of these maintenance flows. FP_A is evaluated according to daily flow values and *FT* is evaluated according to day number within the year. Daily values of *MF* are then calculated.

The maximum daily value of *MF* for a water year is stored as the annual value.

7.5 Recruitment Habitat Condition (RHC) indices

RHC is a weighted sum of a spawning habitat condition index (*SHC*) and a larval-juvenile habitat condition index (*LHC*) (equation 7.4). The normalised weights x_8 and x_9 are locality and group specific.

$$RHC = x_8 SHC + x_9 LHC \qquad 7.4$$

The definitions of *SHC* and *LHC* vary between groups (Table 7.6). The sub-indices referred to in this table are described in Table 7.7. All the sub-indices for *SHC* and *LHC* are both locality and group specific, although of course some are only used for a single group.

Table 7.6 Spawning habitat condition (SHC) and larval habitat condition (LHC) definitions by fish group

Group	Spawning habitat condition (SHC) Equation	Larval habitat condition (LHC) Equation
1	$SHC = SHC_{NF} + (1 - SHC_{NF}) * RR * \sqrt[3]{FM * ST * DR}$	$LHC = LHC_{NF} + (1 - LHC_{NF}) * \sqrt[4]{RF_L * IA * ID * DP}$
2	$SHC = SHC_{NF} + (1 - SHC_{NF}) * RR * \sqrt[3]{SC * ST * DR}$	$LHC = LHC_{NF} + (1 - LHC_{NF}) * \sqrt[3]{IA * ID * DP}$
3	*SHC=1.0*	*LHC=1.0*
4	$SHC = \sqrt[3]{SC * ST * RF_S}$	*If flow below the natural median flow:* $LHC = \sqrt{FP_L * FD}$ *If flow above the natural median flow:* $LHC = \sqrt[3]{IA * ID * DP}$
5, 6	$SHC = \sqrt{ST * RF_S}$	*Same as 4*
7	$SHC = \sqrt{FP_s * ST}$	$LHC = \sqrt{FP_L * FD}$

Table 7.7 Spawning habitat condition (SHC) and larval habitat condition (LHC) index names and definitions

Index	Name	Defined by
SHC_{NF}	Spawning habitat condition (no flood)	Constant index value - user defined
FM	Flood magnitude	Preference curve - user defined
ST	Spawning timing	Preference curve - user defined
RR	Rate of flow rise	Constant threshold value (cm/day) – user defined
DR	Duration of rate of flow rise	Preference curve - user defined
SC	Substrate condition	Group 2: Constant index value based on user defined flushing flow threshold and flushing period Group 4: constant index value - user defined
RF_S	Rate of flow fall (spawning)	Preference curve - user defined
FP_S	Flow percentile (spawning)	Preference curve - user defined
LHC_{NF}	Larval-juvenile habitat condition (no flood)	Constant index value - user defined
RF_L	Rate of flow fall (larval)	Preference curve - user defined
IA	Inundation area	Preference curve - user defined
ID	Inundation duration	Preference curve - user defined
DP	Dry period	Preference curve - user defined
FP_L	Flow percentile (larval)	Preference curve - user defined
FD	Flow duration	Preference curve - user defined

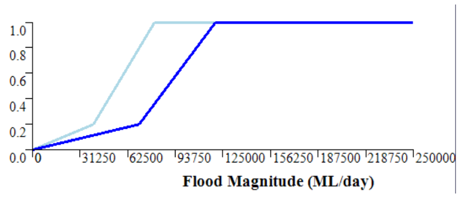
7.6 Spawning Habitat Condition (SHC) indices

Spawning Habitat Condition (No Flood) (SHC_{NF})

For Groups 1 and 2 a constant 'no-flood' spawning habitat condition index value is used to set the minimum value of *SHC*. It indicates that while spawning is enhanced by various flow conditions, some spawning may occur without these conditions.

Flood Magnitude (FM)

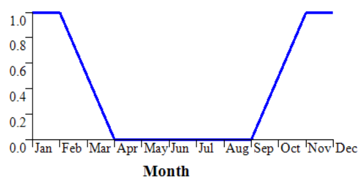
The *FM* (Group 1) preference curve indicates the relationship between the extent of spawning and flow magnitude. The preference curve is defined in terms of daily flow values (ML/day). It is expected that the curve will be used to indicate the much enhanced spawning for Group 1 that occurs during inundation of the floodplains adjacent to the river section.



The value of *FM* that is used for a water year is the *FM* value that helps determine the 'best spawning event' for the water year. This is the event with the maximum product of *FM**ST*DR*, where an event is defined as any period for which *RR*=1. Note this value of FM may not correspond exactly with the flood peak for an event, since the rate of rise may slow to below the threshold (meaning *RR* = 0) while flow continues to rise slowly to a peak value.

Spawning Timing (ST)

The *ST* preference curve indicates the relative preferability of different calendar months for spawning. In ideal spawning months *ST* = 1, while in other months ST <1.

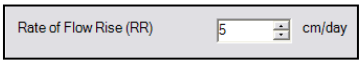


The preference curve is treated as a continuous function, and so daily *ST* values are interpolated from the preference curve according to the day within a calendar month. For groups 4-6 the curve is treated as a discrete monthly function. For Groups 1 and 2 the value of *ST* for a water year is the value for the best spawning event (see definition above). For Groups 4-6 the value of *ST* for a water year is the value coincident in time with the minimum value of RF_S during the period for which *ST*>0. For Group 7 all the daily *ST* values are considered: the annual value of *ST* is the daily value which gives the median non-zero product of the daily *ST* and FP_S values.

Although fish spawning is known to be dependent on water temperature, MFAT does not have temperature preference curves as scenario water temperature data are not available. However, to represent known thermal pollution effects on spawning, the *ST* preference curve can be used. Do this by reducing the index value during the preferred spawning months by an appropriate amount to represent the degree to which thermal pollution inhibits spawning.

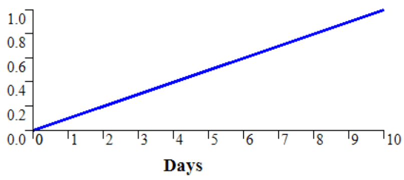
Rate of Flow Rise (RR)

For Groups 1 and 2 a rate of flow rise (depth increase – cm/day) threshold is the trigger that defines spawning events. *RR* = 1 when the rate of rise is equal to or above the threshold value, and



RR = 0 when the rate of rise is below this threshold. A spawning event is a period for which *RR* is continuously equal to 1. Separate threshold rate of rise values may be specified for each of these two groups.

Duration of Rate of Rise (DR)



The *DR* preference curve indicates the relative preferability of different durations (in number of days) for which the rate of flow rise remains above the threshold value (*RR* = 1). Each spawning event therefore has a single *DR* value.

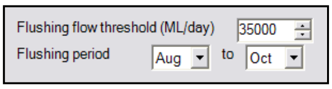
Substrate Condition (SC)

Groups 2 and 4 lay sticky eggs and a suitable substrate is required for successful spawning.

For Group 2 clean gravels are required and it is therefore assumed that a flushing flow is required

Value	Description
1	Flushed
0.5	Not flushed

in the period prior to spawning. For Group 2 therefore *SC* for a water year is either the ‘flushed’ value or the ‘unflushed’ value. These two values can be set by the user.



The value for a water year is determined by wether or not a flow has exceeded a user-specified ‘flushing flow’ threshold during a user-specified ‘flushing period’.

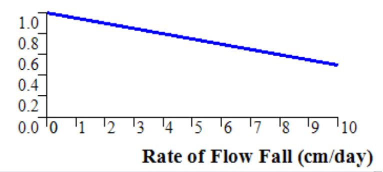
For Group 4 *SC* takes one of four values for a water year. These different values are user-set, and correspond to fixed qualitative descriptions of substrate condition. Substrate for Group 4 includes aquatic macrophyte beds and snags.

Table 7.8 Substrate condition (SC) classes and default values – for group 4 only

Substrate condition class for catfish	Default value
Abundant suitable substrate	1.0
Moderate suitable substrate	0.7
Limited suitable substrate	0.3
No suitable substrate	0.0

Rate of Flow Fall (RF_S)

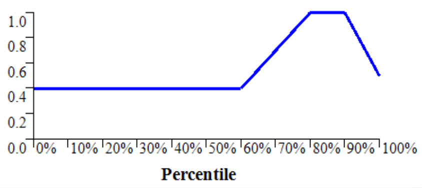
The RF_S preference curve indicates the preferred rates of flow fall (cm/day). Unnaturally high rates of flow fall are detrimental as they cause fish nests and eggs to be exposed due to falling water levels, and in danger of desiccation.



RF_S is assessed daily and the annual value for a water year is the minimum value for the period in which *ST*>0.

Flow Percentile (FP$_S$)

The FP_S preference curve indicates the preferred flow range for Group 7 spawning in terms of percentiles of the natural daily flow duration curve.



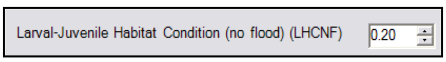
Group 7 are low flow specialists and so it is expected that this preference curve will indicate a strong preference for low flow percentiles. For Group 7, all the daily FP_S values are considered: the annual value of FP_S is the daily value which gives the median non-zero product of the daily *ST* and FP_S values.

7.7 Larval Habitat Condition (LHC) indices

LHC is assessed over the eight weeks post-spawning; that is, the annual values for LHC sub-indices are drawn from the daily sub-index values calculated during this period. For Groups 1 and 2, spawning is a single event (triggered by *RR*>0), and hence the period for *LHC* assessment is well constrained. For Groups 4, 5, 6 and 7 there may be multiple *SHC* maxima, so the *LHC* assessment period is from the first *SHC* maximum until eight weeks after the last maximum.

Larval-juvenile Habitat Condition (No Flood) (LHC_{NF})

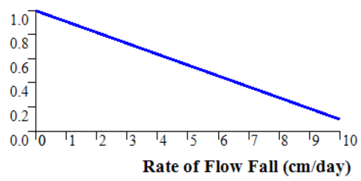
For Groups 1 and 2 a constant 'no-flood' larval-juvenile habitat condition index value is used to set the minimum value of *SHC*.



It indicates that while larval-juvenile success is enhanced by various flow conditions, some survival through this life stage may occur without these conditions.

Rate of Flow Fall (RF_L)

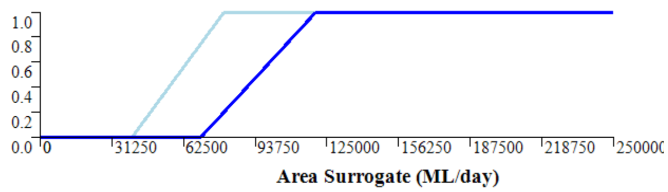
The RF_L preference curve indicates the preferred rates of flow fall (cm/day) for larval-juvenile habitat for Group 1.



Unnaturally high rates of flow fall are detrimental as they can lead to larvae or juveniles being stranded in floodplain wetlands, leaving them vulnerable to predation. The RF_L value for the *LHC* assessment period (and hence water year) is the minimum daily value for the 'best inundation event' (see below).

Inundation Area (IA)

The larvae and juveniles of all groups except Group 7 take advantage of floodplain inundation, through the associated increase in food resources and reduction in predation pressure.

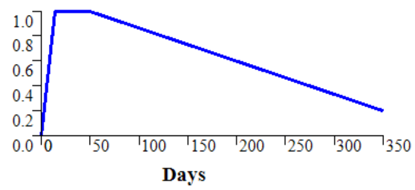


The *IA* preference curve indicates the aspects of this response related to the extent of inundation. Although MFAT includes a floodplain hydrology model that predicts inundated area, this is not explicitly associated with separate river sections, nor does it necessary model the entire floodplain. Because of this the *IA* preference curve is defined in terms of daily flow values (ML/day) instead of actual areas of inundation.

The *IA* value for the *LHC* assessment period (and hence the water year) is the maximum daily *IA* value for the 'best inundation event' with this defined as the inundation event with the highest product of *IA*, *ID* and *DP*.

Inundation Duration (ID)

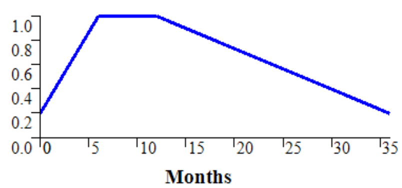
The *ID* preference curve indicates the aspects of floodplain inundation response related to the duration of inundation.



The *ID* preference curve is defined in terms of the number of days for which overbank flow is exceeded. The *ID* value for the *LHC* assessment period (and hence the water year) is the *ID* value for the 'best inundation event', determined by the number of days during the best inundation event the flow remains above bankfull.

Dry Period (DP)

The *DP* preference curve indicates the aspects of floodplain inundation response related to the duration (in months) of the dry period prior to inundation. The *DP* preference curve is defined in terms of the number of months for which the floodplain was not inundated before the 'best inundation event'.

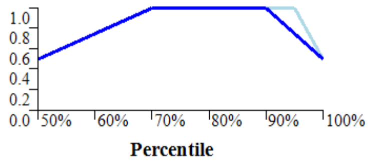


The preference curve is treated as a continuous function not a stepwise function. Daily *DP* values are therefore interpolated from the preference curve according to the duration to the dry period in days.

The *DP* value for the *LHC* assessment period (and hence the water year) is the *DP* value for the 'best inundation event', determined by the number of months before the best inundation event that the flow remains below bankfull.

Flow Percentile (FP_L)

The FP_L preference curve indicates the relative preferability for larval-juvenile habitat of different flow magnitudes, expressed in terms of percentiles of the natural daily flow duration curve.

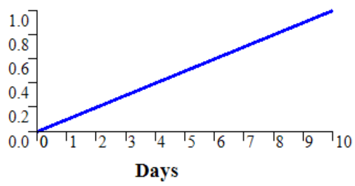


For Groups 4-6 dual mode recruitment is assumed, with different modes of recruitment occurring at high flow percentiles and at low flow percentiles. In the high flow recruitment mode the sub-indices *IA*, *ID* and *DP* are used to define larval-juvenile habitat condition. In the low flow recruitment mode FP_L is combined with a flow duration (*FD*) sub-index (see below). For the low flow recruitment mode for these groups an FP_L preference curve is used to indicate the low flow preferences in this dual mode recruitment model. The FP_L preference curve for Groups 4-6 is defined in terms of percentiles of the natural daily flow duration curve between the natural median (50th percentile) and the natural minimum (100th percentile).

For Group 7 – low flow specialists – a single recruitment mode is assumed and the FP_L preference curve is used to indicate the relative preferability for *LHC* of all flows in terms of percentiles of the natural daily flow duration curve. It is expected that the low flows (high percentiles) will have the highest values on the preference curve. However, the high flows (low percentiles) may have non-zero values indicating some larval-juvenile survival at higher flows.

The FP_L value for the *LHC* assessment period (and hence the water year) is the median value for the *LHC* assessment period.

Flow Duration (FD)



The *FD* preference curve indicates the relative preference of the durations (in days) for which FP_L>0 for Groups 4-7. The *FD* value for the *LHC* assessment period (and hence the water year) is the median value for the *LHC* assessment period.

7.8 Setting up the model

Step 1 - define locality

The first step is to define the locality – which must be of type 'river section'. The river section is named, its extent within the zone defined, and the relevant flow file (imported from the external river hydrology model) is specified. The locality is described by a series of scenario flow data from a single node along the river.

Step 2 - specify fish groups

The next step is to select the fish groups relevant to this locality. Relevant species may include those currently present in the river section, and also those which might have been present under pre-settlement conditions.

Step 3 - order of data entry

Ensure all the necessary preference curves, weights and other required parameters are entered for each fish group of relevance at this locality. It is probably best to begin with the weights, then move to the adult habitat component of the model, then deal with the recruitment habitat component – first the spawning component and then the larval-juvenile component.

Step 4 –assign weights
There are three sets of weights to be set for each locality

- weighting to each fish group, of adult and recruitment stages
- weighting to each fish group, of influence of woody debris, fish passage, thermal pollution, and maintenance flow on adult habitat condition
- weighting to each fish group, of spawning and larval stages within the recruitment stage.

Default values are provided, together with the evidence or justification of these values. These values can be changed if there is reasonable evidence to do so. The evidence should be documented in the **Evidence** forms. The weights control the relative importance of the different indices to the overall fish habitat condition (FHC). The weights can be different for each fish group.

Step 5 – set adult habitat condition indices
For the adult habitat component there are some indices that describe the locality (from a fish habitat perspective) and are the same for all fish groups. These are in the dark grey panel at the top of the adult habitat condition (AHC) tab. These include 'woody debris', 'thermal pollution' and 'channel condition'. For all of these indices, choose the various conditions that best describe the locality. For all of these indices the <u>index values</u> associated with these descriptions can be edited. These control the influence these aspects of habitat have on adult habitat condition (AHC), and indeed on the overall fish habitat condition (FHC).

Of course, the weights which have already been set also provide control of relative influence, so there is plenty of scope for adjusting the model. Ideally, use the natural flow scenario to adjust the relative importance of flow-related habitat degradation, and non-flow habitat degradation. Also use the natural flow scenario to ensure that the variability of adult habitat condition (AHC) under 'pre-disturbance' conditions is realistic. To check results for this and other model components, move to the 'diagnostics' tab after running the model with the adjusted input parameters.

Step 6 – define adult habitat condition preference curves
There are only two preference curves used in adult habitat condition (AHC). These are to determine the Maintenance Flow (MF) index, and are 'Flow timing' and 'Flow percentile'. Default preference curves are provided, but might need adjusting. The evidence for any changes should be provided in the Evidence forms.

Step 7 –define spawning habitat condition indices and preference curves
For the spawning habitat component the relevant indices vary considerably between groups, as indicated on the tab when you change group selection. In each case, default preference curves are provided. Some preference curves are locality specific, such as 'flood magnitude', and must be adjusted to suit each locality being assessed. Others might be common to all localities but still must be specified for each locality. If default curves are adjusted, the evidence for these changes should be provided in the Evidence forms.

Step 8 – define larval-juvenile habitat condition indices and preference curves
For the larval-juvenile habitat component, the relevant indices vary considerably between groups, as indicated on the tab when you change group selection. In each case, default preference curves are provided. Some preference curves are locality specific, such as 'inundation area', and must be adjusted to suit each locality being assessed. Others might be common to all localities but still must be specified for each locality. If default curves are adjusted, the evidence for these changes should be provided in the 'evidence' windows.

Step 9 – run the model

The model is run using the controls on the left panel to select the group and locality. A batch run will run all groups and localities, for every flow scenario, using the current settings. The index and sub-index outputs for the latest run can be viewed on the 'diagnostics' tab. Use the check boxes to select for which indices you wish to view the annual time series, again using the left-hand panel to select the group and locality to be displayed.

Step 10 – analyse results

The MFAT Explore tool provides various statistics and spell analyses on the model output, but only on the group-integrated fish habitat condition index time series.

Table 7.9 Summary of data input and preference curves for native fish

Data or Preference Curve	**Groups**	**X-axis**
SC_CatfishSubstrateCondition	4	
SC_SubstrateFlushingCondition	4	
Flow threshold	all	ML/day
Migration start month	all	Calendar month
Migration end month	all	Calendar month
FT_FlowTiming preference curve	3	Calendar month
FPA_FlowPercentile(Adult) preference curve	3	0-100%
SHCNF_'no flood' spawning	1,2	Constant
LHCNF_LarvalHabitatCondition(noflood)	1,2	Constant
FM_SpawningFloodMagnitude preference curve	1	ML/day
ST_SpawningTiming preference curve	1,2,4,5,6,7	Calendar months
RR_RateOfFlowRiseThreshold	1,2	Constant
DR_RateOfFlowRiseDuration preference curve	1,2	Days
FPS_Flowpercentile(Spawning) preference curve	7	0-100%
RFS_RateOfFlowFall(Spawning) preference curve	4,5,6	Cm/day
RFL_RateOfFlowFall(Larval) preference curve	1	Cm/day
FD_FlowDuration	4,5,6,7	Days
IA_InundationArea	1,2,4,5,6	Ha
ID_InundationDuration	1,2,4,5,6	Days
DP_DryPeriod	1,2,4,5,6	Days
FPL_FlowPercentile(Larval)	4,5,6,7	0-100%

8 ALGAL GROWTH MODEL

8.1 Model development

The structure of the MFAT Algal Growth model is largely unchanged from that developed for the Environmental Flows Decision Support System (EFDSS). The EFDSS Algal growth model was based on interviews with Myriam Bormans and Ian Webster in 1996, and published literature. Its conceptualisations are documented in Young *et al.* (1999), Bormans and Webster (1997), Webster *et al.* (1996) and diagrammatically in Appendix C, Figure C.6.

Evidence supporting the MFAT input data is recorded in the Evidence tables in the ALGAE database for each river zone. This evidence has been prepared by the CRCFE and regional evaluation groups.

8.2 Summary Description

The Algal Growth model enables simulation of the likely algal populations in weir pools in the lowland rivers of the Murray-Darling Basin under different river flow scenarios. The model is particularly intended for blue-green algae which take advantage of thermally stratified water bodies. The model is run for localities of type 'weir pool'.

The input data are

- simulated daily river discharges (and average daily flow depths and flow velocities)
- mean monthly turbidity levels (NTU)
- mean monthly air temperatures – minimum and maximum (deg C)
- mean monthly relative humidity (%)
- mean monthly wind speed (m/s)
- various algal population parameters
- weir pool location (latitude) and width (m).

The model undertakes an hourly energy balance (considering net surface heat flux, net downward shortwave radiation, net upward long wave radiation, net sensible heat flux, and the heat flux due to evaporation) and compares this to the kinetic energy of the river flow to determine whether the water column stratifies on any given day.

While the water column is stratified, the algal population grows (up to a maximum), and while unstratified the population decays (down to a minimum). Note that growth is restricted to the spring-summer period, irrespective of stratification[8].

Algal species

The model can be run for any algal species (by assigning the appropriate parameter values), but is intended for species that take advantage of stratification by adjusting cell buoyancy to move into the euphotic zone. Default parameters for *Anabaena circinalis* have been included in MFAT.

[8] Introduced in MFAT v1.3

8.3 Algal Index values

The algal population is actually a cell concentration (cells/ml), and daily algal index values are determined according to cell count value.

Table 8.1 Cell counts and algal index values

Cell Count	Algal Index	Alert Level	Range	Description
1	0	None	0 - <200 cells/ml	No algal toxin risk
200	-0.2	None	200 - 2,000 cells/ml	Low algal toxin risk
2000	-0.5	Low	2,000 - 15,000 cells/ml	Moderate algal toxin risk
15000	-0.8	Moderate	15,000 - 100,000 cells/ml	High algal toxin risk
100000	-1	High	>= 100,000 cells/ml	Extreme algal toxin risk

The annual algal index is the arithmetic mean of the daily values for the months September to April (ie. the warmer months).

Annual algal index values are restricted to the range 0 (for no algal toxin risk) to -1 (for extreme algal toxin risk)[8]. While the annual index value is constrained, daily index values against daily cell counts are not bounded and so can be set to allow large blooms to dominate the annual index value.

8.4 Setting up the model

Step 1 – define locality

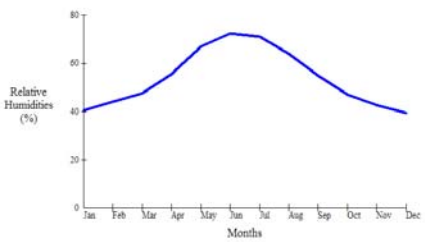
Firstly, define and name the locality – which must be of type ‘weir pool’. This includes

- the latitude of the weir pool
- its average width (m).

Step 2 – define climate data

The following climate and water quality data needs to be provided

- daily average wind speed – average values for each of the twelve calendar months
- daily average relative humidity – average values for each of the twelve calendar months
- daily maximum and minimum air temperatures – average values for each of the twelve calendar months
- average monthly turbidity data in NTU.



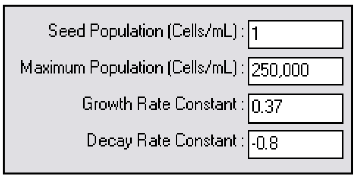
The default values provided with MFAT are for the Border Rivers in the north of the Murray-Drling Basin and need to be replaced with data for the locality being assessed. These can be entered using the same graphing tool as that used for preference curves in other models.

Step 3 – parameterise species

Specify and parameterise the algal species (one or more) that are to be modelled.

The required parameters are

- a ‘seed’ (or minimum) population size (cells/ml)



- a maximum population size (cells/ml) (for example, as limited by nutrient availability)
- a growth rate used in exponential growth function
- a decay rate used in exponential decay function.

Step 4 – run the model

The model is run using the controls on the top panel to select the species, locality and flow scenario. A batch run will run all groups, all localities and all flow scenarios, using the current settings. The stratification index (0= unstratified 1= stratified), the cell counts and the cumulative days stratified for the latest run can be viewed using the ‘graph’ button.

Step 5 – analyse results

The MFAT Explore tool provides various statistics and spell analyses on the model output, but only on the group-integrated annual algal index time series.

9 THE MFAT EXPLORE TOOL

9.1 Summary Description

The MFAT Explore Tool is designed for the following purposes:

- to graph hydrologic and ecological model outputs for different flow scenarios
    - as time series
    - cumulative distribution functions (CDF)
    - seasonal pattern (hydrology only),
- to graph and tabulate a range of pre-defined indicators based on the times series data for hydrologic and ecological model outputs,
- to enable spell analyses of hydrologic and ecological model outputs,
- to enable export of tabulated and graphed data for further spreadsheet analyses.

The comparisons, spell analyses and statistics of the raw hydrology data and ecological model outputs are accessed under the ‘statistics’ tab. The comparisons, spell analyses and statistics of the various indicators are accessed under the ‘indicators’ tab.

9.2 Comparisons

The following three types of comparison are provided for:

Within zone comparisons

This feature enables comparisons between a test scenario and a reference scenario within a single zone. These comparisons can be made for a various single assessments and integrated assessments, and for one or all localities within the zone.

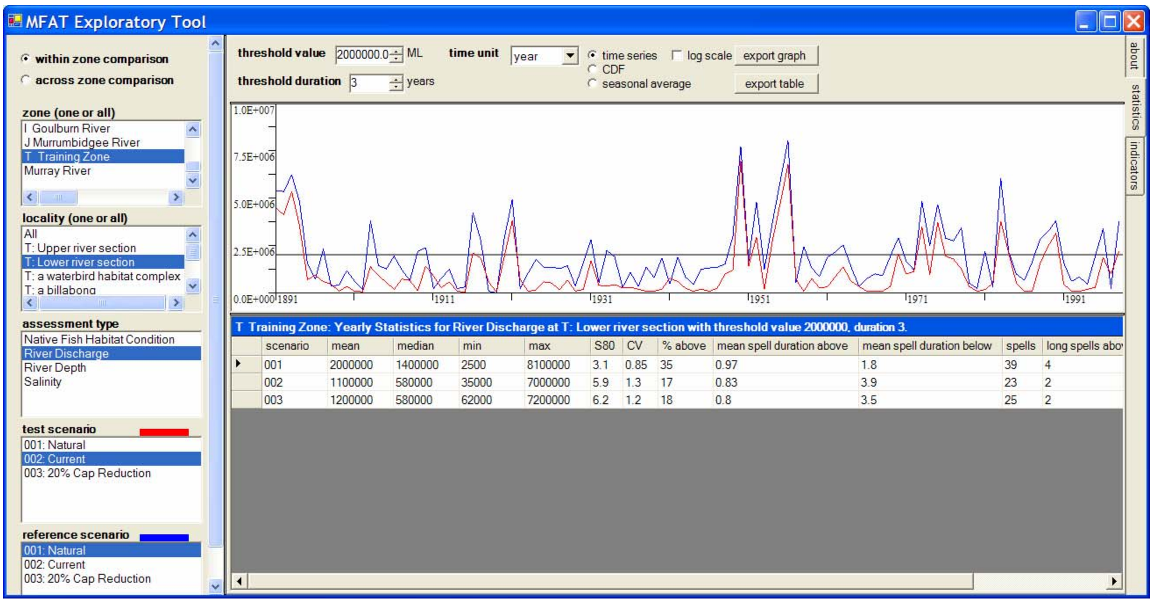


Figure 9.1 Example of within zone comparison, time series graph

Between zones comparisons

This feature enables comparisons between a one zone (test) and another zone (reference) for a single scenario. These comparisons can be made for various single assessments and integrated assessments.

Floodplain investigations

This feature enables comparisons between a test scenario and a reference scenario for individual elements of a selected floodplain configuration, including all pipes and storages.

9.3 Localities

Assessments can be integrated over all or a selection of localities. Establishing the subset of localities for integration is provided through the Explore interface. Of course, some assessment types are not available for some locality types or localities (eg assessment of fish habitat condition is not possible for wetlands, and assessment of say, a particular fish group at a particular locality is only available if that association (assessment with locality) has been made).

9.4 Integrated Assessments

Explore provides access to all assessment results produced by the assessment models. It also calculates and displays integrated assessments for the following combinations of assessments and localities (or selected sub-sets of localities):

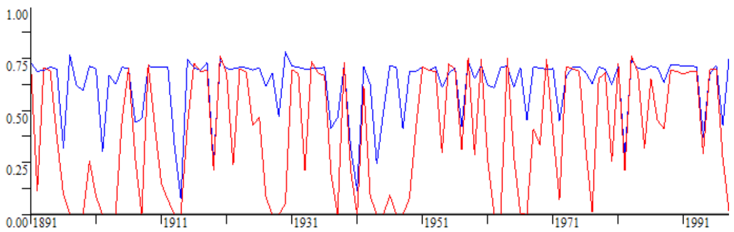
- river health – integrates all assessments for all selected localities
- instream health - integrates native fish and algal bloom assessments for all selected ‘river section’ and ‘weir pool’ localities
- floodplain health – integrates waterbird, wetland and floodplain vegetation habitat condition assessments for selected ‘waterbird complex’, ‘floodplain’, ‘billabongs/lagoons’ and ‘riverine lakes’ localities

Regardless of the assessment type and the number of localities, the default result of each assessment is a time series graph of integrated condition and a table of statistics for each selected scenario. By default, the graph plots the natural and current scenarios.

9.5 Graphs

Time series

These graph the annual indices or indicators for model outputs, and graph the daily, monthly or yearly values or indicators for:

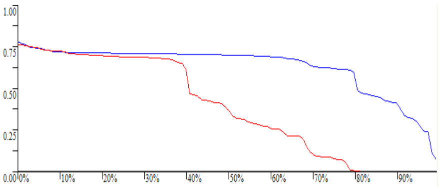


- river discharge
- river depth
- water quality (salinity, mouth-opening index)
- inundated area
- inundation volume

For these latter measures choose the ***time unit*** (day, month, year) from the drop-down list box, and toggle the logarithm base 10 scale on or off with the check box.

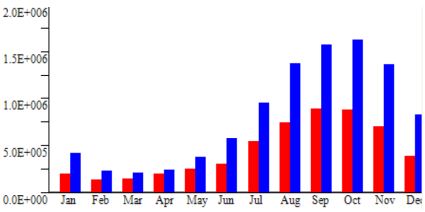
CDF – cumulative distribution function

These graph hydrology data, water quality (salinity, mouth opening index) data, index or indicator values as a function of the probability of exceedance. For flow data, this is known as a ‘flow duration curve’.



For hydrologic and water quality (salinity, channel index) data, choose the ***time unit*** from the drop-down list box.

Seasonal average



For hydrology and water quality (salinity, mouth opening index) data only, these graph the average monthly values for each calendar month.

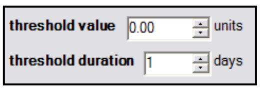
9.6 Statistics

The following statistics are calculated and tabulated for hydrologic data, water quality (salinity) data, indices and indicators:

- mean (average)
- median (50th percentile)
- minimum
- maximum
- S80 – difference between the 10th and 90th percentiles divided by the 50th (10th – 90th)/50th
- coefficient of variation (CV), standard deviation divided by the mean

9.7 Spell Analyses

Spell analyses can be performed on the hydrology data, water quality (salinity, mouth opening index) data, index model outputs, and various indicators.



Spell analyses are performed based on a user-specified threshold value, and a user-specified spell duration threshold. The threshold value and the threshold duration are specified in the graph control box. The threshold value can also be specified by clicking on the graph.

Using these values spell analyses calculate the following statistics

- percent of values above the specified threshold value
- mean duration of spells above the specified threshold value
- mean duration of spells below the specified threshold value
- total number of number of spells
- number of long (greater than specified threshold duration) spells above specified threshold value
- number of long (greater than specified threshold duration) spells below specified threshold value.

9.8 Indicators

Under the **Indicators** tab, the graphs and tabulations of statistics and spell analyses described above can be performed for a number of pre-defined indicators. The selection box for 'reference scenario' is greyed out when on the **Indicators** tab, because the reference scenario is pre-defined in the indicator definitions – see below.

The indicators are applied to hydrologic data, water quality (salinity) data, and index model outputs. The indicators are all dimensionless ratios of values, with the denominator representing a 'reference' condition definition, and the numerator a 'test' measure. The indicators are selected using a drop-down list box.

The following pre-defined indicators are available:

- S/N - test scenario as a ratio of the 'Natural' scenario
- S/R - test scenario as a ratio of the 'Reference' scenario
- S/C - test scenario as a ratio of the 'Current' scenario
- C/N - the 'Current' scenario as a ratio of the 'Natural' scenario
- C/R - the 'Current' scenario as a ratio of the 'Reference' scenario
- R/N - the 'Reference' scenario as a ratio of the 'Natural' scenario
- [abs(S–C)/(N–C)] - the absolute value of the difference between a test scenario and the 'Current' scenario as a ratio of the difference between the 'Natural' scenario and the 'Current' scenario

The full-scale value for the indicator graphs is set to 2.0 – larger ratio values are not displayed. This value is used when the denominator is zero, and the numerator is not zero. When the denominator and the numerator are zero, the indicator value is set to 1.0.

9.9 Export

From both the **Data** and the **Indicators** tabs, facilities are provided to export tabulated and graphed values to comma-separated files (*.csv) files.

Select a directory and specify a file name for saving. The graph values are stored as (date, value) for 'indicator' time series, (date, test value, reference value) for 'statistic' time series, (percentile, value) for indicators CDF, (percentile, test value, reference value) for 'statistic' CDF, and (calendar month, test value, reference value) for 'statistic' seasonal average.

9.10 Final note about running Explore

To perform group level integration, MFAT Explore requires that all relevant groups (not all scenarios) have been run. It will give an error message if this is not the case. It will also warn when scenario runs are missing.

10 REFERENCES

Bormans M and IT Webster (1997) A mixing criterion for turbid rivers. *Environmental Modelling and Software*, 12(4), pp329-333.

Lam DCL, CI Mayfield, DA Swayne and K Hopkins (1994) A prototype information system for watershed management and planning *J. Biological Systems*, 2(4), pp499-517.

Podger GM, PK Sharma and DC Black (1994) An integrated water quantity and quality modelling suite. Proceedings of Environmental Flows Seminar, AWWA, Australia.

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Young WJ, SM Cuddy, FM Marston and TFN Farley (1999) Environmental Flows Decision Support system A Prototype. Volume 1 – System Description and Volume 2 – Technical Supplement. CSIRO Land and Water Technical Report 11/99, CSIRO Land and Water, Canberra.

Appendix A INSTALLING MFAT

Note: These instructions assume that the MFAT programs are distributed on the same disk as the databases, this may not be the case.

The MFAT distribution disk has the following directory structure:

MFAT	Contains all the programs and other controls required to run the programs
MFAT\Systems	Contains programs which you may need to install if your computer does not have Microsoft .NET installed
MFAT\ZoneX	Contains a set of databases which store the model inputs and results for one zone of the Murray. The last character (X) is the Zone identifier, eg A

A.1 Installing the programs and databases

Step 1 – Copy software
Insert the MFAT distribution disk into your CD drive.

Using Windows explorer, copy the MFAT directory and its sub-directories from the CD onto your hard disk. (All further instructions refer to this directory as the MFAT root directory).

It is assumed that you will install into C:\MFAT. If this is not the case, you will need to tell MFAT. MFAT stores such information in a small text file which sits in the MFAT root directory. This file is called mfat.ini.

Step 1b – Ensure that MFAT points to right directories
Edit mfat.ini (using NotePad or a similar text editor) and ensure that the Root entry points to the right place. For example:

Root=c:\mfat

The name of the sub-directory containing the databases may depend on the River Zone that you are installing. Edit the DataPath and StaticDataPath entries in mfat.ini. For example:

DataPath=\ZoneA
StaticDataPath=\ZoneA

Step 2 – Put a shortcut on your desktop
MFAT does not automatically provide an icon on the desktop, or an entry in the Start Programs menu. You will need to do this manually. Using Windows Explorer, go to the MFAT root directory. Right click on MFLaunch.exe and drag it to your desktop. When you release the right button, select the ‘Create shortcut(s) here’ menu option.

Step 3 – Run
You can now launch MFAT by selecting the desktop icon (by clicking or double clicking, depending on your mouse settings).

The PUBLIC VERSION (ie read-only mode) of MFAT v1.4 will be launched and the splash screen will appear. This mode allows you to view and analyse all data, but not make any changes that modify the databases.

If you get strange messages at this point, you probably need to load the .NET software. Go to the next section, Installing Supporting Software.

A.2 Installing Supporting Software

Many of the MFAT programs use the Microsoft .NET platform. While most of this is distributed with the Windows operating system, there are occasions when computers don't have all the required files. These are provided on the distribution disk in the \Systems directory.

Three executables are provided on the distribution disk:

- dotnetfx.exe
- mdac_typ.exe
- jet40SP3_comp.exe

Using Windows Explorer, copy these three files from the \Systems disk to your \Downloaded Files or \Temp directory.

Step 1 - install .NET

Select and run dotnetfx.exe (by clicking or double clicking on the file name in Windows Explorer, or by using the Start|Run|Browse dialog). YOU NEED ADMINISTRATOR PRIVILEGES ON YOUR COMPUTER TO DO THIS. A license agreement window (Figure A.1) will appear.

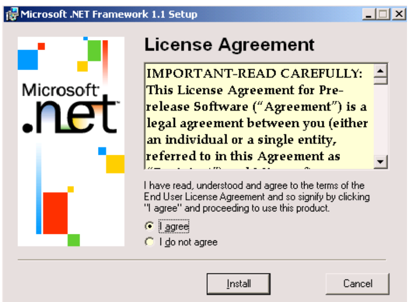

Figure A.1 .NET Licence agreement form

Click 'I agree' and continue with the install procedure which will take some time. When completed, you may need to restart your computer. The .NET installation will let you know this.

Try to run MFAT again. If you still get strange messages, then you probably need to load the data access components software. Continue to Step 2.

Step 2 – install .Data Access Components

Select and run mdac_typ.exe (by clicking or double clicking on the file name in Windows Explorer, or by using the Start|Run|Browse dialog).

Select and run Jet40SP3_comp.exe.

You must restart your computer at this stage.

A.3 Trouble Shooting

Still getting .NET error messages

If you have problems which mention .NET, then it is probably because you haven't a full installation of this Microsoft software. The necessary files are provided in the System directory on the install disk.

Getting error message which mentions IE

Microsoft .NET requires a relatively recent version of Internet Explorer. Check your version number.

Not finding databases

This is probably a typo in the mfat.ini file. An example of the top part of the file is below.

```
# ======================================
# Murray Flow Assessment Tool
# Name:  mfat.ini
# purpose: provide path to MFAT Zone
# ======================================
[General]
Root=c:\MFAT
[Database]
DataPath=\ZoneA
StaticDataPath=\ZoneA
```

Figure A.2 Content of mfat.ini configuration file

Ensure that DataPath and the StaticDataPath point to your Zone.

Can't update databases (for those with read-write mode)

Sometimes copying databases to CDs sets the read-only property. To change this, select all the *.ldb and *.mdb files (using Windows Explorer). Right click and select Properties, then des-select the 'read only' check box.

Appendix B MFAT FILES AND DATABASE STRUCTURE

B.1 MFAT executables and other files

Directory	Filename	Content
Systems	*.exe	Microsoft .NET and data access components distributable executables
MFAT	mfat.ini	Text file containing paths for finding databases. May need to be edited using NotePad
	MFATalga.exe	Algal growth model executable
	MFATBird.exe	Waterbird model executable
	MFATFYHD.exe	Floodplain hydrology model executable
	MFATFish.exe	Native fish model executable
	MFATWVeg.exe	Aquatic wetland vegetation model executable
	MFATFVeg.exe	Floodplain vegetation model executable
	MFLaunch.exe	MFAT PUBLIC VERSION (read-only) executable
	MFW8Setc.exe	Weights and Connections executable
	MFXplore.exe	MFAT-Explore executable
	MFATKit.dll	MFAT DLL
	EvidenceForm.dll	Evidence Recording Form dll
	Ini.dll	MFAT DLL
	PreferenceCurveForm.dll	MFAT DLL

The Restricted version (ie read-write mode) has a separate version of the MFLaunch executable, MFLaunchrw.exe.

B.2 MFAT databases and tables

MFAT consists of a set of databases containing tables which store both input data and results of model runs. These differ somewhat from those developed for the earlier EFDSS in that most tables were renamed to include their short form used in equations (eg WD for water depth); and because modifications to some models required more tables. In addition, tables were added to each database to record evidence and confidence. The tables within each database are listed below. Type indicates whether the table contents were entered by the user as straight description (Input) (InputCurve), as a preference curve ((InputPrefCurve), or calculated by MFAT (Output, OutputIndex). Database table names are grouped by Type in the following tables.

(Floodplain) volumes database (VOLUMES.MDB) and tables

Table Name	Type	Key (multiple)		
OverallConfidence	Evidence	ZoneID		
AssessmentConnections	Input		LocalityID	
BirdAssessmentConnections	Input		LocalityID	CID
Configurations	Input			CID
Pipes	Input			CID, PID
Positions	Input			CID, SID
Storages	Input			CID, SID
StorageVolumeAreas	InputCurve			CID, SID, Volume
PipeVolumes	ModelledOutput	ScenarioID		CID, PID
StorageAreas	ModelledOutput	ScenarioID		CID, SID
StorageVolumes	ModelledOutput	ScenarioID		CID, SID

Wetland vegetation habitat assessment database (WVEGHAB.MDB) and tables

Table name	Type	Key (multiple)		
EvidenceKeyedByLocalityGroup	Evidence		LocalityID	Group
EvidenceKeyedByZone	Evidence	ZoneID		
EvidenceKeyedByZoneGroup	Evidence	ZoneID		Group
OverallConfidence	Evidence	ZoneID		

Table name	Type	Key (multiple)		
ConditionWeights	Input		LocalityID	VegetationID
Connections	Input		LocalityID	VegetationID
VegetationCategoryEditFlags	Input			VegetationID
VegetationGroups	Input			VegetationID
DC_RateOfDepthDecrease	InputPrefCurve			VegetationID, Version x,
DI_RateOfDepthIncrease	InputPrefCurve			VegetationID, Version x,
FT_InundationTiming	InputPrefCurve			VegetationID, Version x,
ID_InundationDepth	InputPrefCurve			VegetationID, Version x,
IP_InterPeriod	InputPrefCurve			VegetationID, Version x,
PD_DepthDuration	InputPrefCurve			VegetationID, Version x,
RD_RateOfDepthChange	InputPrefCurve			VegetationID, Version x,
RT_RecruitmentTiming	InputPrefCurve			VegetationID, Version x,
WD_WaterDepth	InputPrefCurve			VegetationID, Version x,
StorageVolumes (not used MFAT)	Output	ScenarioID	LocalityID	VegetationID
AHC_AdultHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
DC_RateOfDepthDecreaseIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
DI_RateOfDepthIncreaseIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
FT_InundationTimingIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
ID_InundationDepthIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
IP_InterPeriodIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
PD_DepthDurationIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
RC_RateOfDepthChangeIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
RHC_RecruitmentHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
RT_RecruitmentTimingIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
WD_WaterDepthIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
WHC_VegetationHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	VegetationID

Floodplain Vegetation habitat assessment database (FVEGHAB.MDB) and tables

Table Name	Type	Key (multiple)		
EvidenceKeyedByLocalityGroup	Evidence		LocalityID	Group
EvidenceKeyedByZone	Evidence	ZoneID		
EvidenceKeyedByZoneGroup	Evidence	ZoneID		Group
OverallConfidence	Evidence	ZoneID		
ConditionWeights	Input		LocalityID	VegetationID
Connections	Input		LocalityID	VegetationID
VegetationGroups	Input			VegetationID
FM_Thresholds	Input			VegetationID
DD_InundationDuration	InputPrefCurve			VegetationID, Version, x
DP_InterFloodPeriod	InputPrefCurve			VegetationID, Version, x
FD_InundationDuration	InputPrefCurve			VegetationID, Version, x
FM_FloodMemory	InputPrefCurve			VegetationID, Version, x
FT_FloodTiming	InputPrefCurve			VegetationID, Version, x
GT_GerminationTiming	InputPrefCurve			VegetationID, Version, x
ID_InundationDepth	InputPrefCurve			VegetationID, Version, x
StorageVolumes	Output	ScenarioID	LocalityID	VegetationID
AHC_AdultHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
DD_InundationDurationindex	OutputIndex	ScenarioID	LocalityID	VegetationID
DP_InterFloodPeriodIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
FD_InundationDurationIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
FM_FloodMemoryindex	OutputIndex	ScenarioID	LocalityID	VegetationID
FT_FloodTimingIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
GT_GerminationTimingIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
ID_InundationDepthIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
RHC_RecruitmentHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	VegetationID
VHC_VegetationHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	VegetationID

Waterbird habitat assessment database (BIRDHAB.MDB) and tables

Table Name	Type	Key (multiple)		
EvidenceKeyedByLocalityGroup	Evidence		LocalityID	Group
EvidenceKeyedByZone	Evidence	ZoneID		
EvidenceKeyedByZoneGroup	Evidence	ZoneID		Group
OverallConfidence	Evidence	ZoneID		
BHC_BreedingHabitatConditionWeights	Input			Group
BirdSpecies	Input			Group
BreedingThresholdIndexLevels	Input			GERange
Connections	Input		LocalityID	Group
NV_NestingVegetation	Input	ScenarioID	LocalityID	Group
NV_NestingVegetationDesc	Input	NestingVegetationClass		Group
AI_AreaInundated	InputPrefCurve		LocalityID	Group, Version, x
AI_ForagingAreaInundated	InputPrefCurve			Version, x
DP_DryPeriod	InputPrefCurve		LocalityID	Group, Version, x
FD_FloodDuration	InputPrefCurve			Group, Version, x
RF_RateFall	InputPrefCurve			Group, Version, x
WDV_ForagingWaterDepthVariability	InputPrefCurve			Version, x
WHC_WaterbirdHabitatConditionweights	InputPrefCurve			Group
StorageVolumes	Output	ScenarioID	LocalityID	Group
AI_AreaInundatedIndex	OutputIndex	ScenarioID	LocalityID	Group
AI_ForagingAreaInundatedIndex	OutputIndex	ScenarioID	LocalityID	
BHC_BreedingHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	Group
DP_DryPeriodIndex	OutputIndex	ScenarioID	LocalityID	Group
FD_FloodDurationindex	OutputIndex	ScenarioID	LocalityID	Group
FHC_ForagingHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	
RF_RateOfFallindex	OutputIndex	ScenarioID	LocalityID	Group
WDV_ForagingWaterDepthVariabilityIndex	OutputIndex	ScenarioID	LocalityID	
WHC_WaterbirdHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	

Native fish habitat assessment database (FISHHAB.MDB) and tables

Table Name	Type	Key (Multiple)		
EvidenceKeyedByLocalityGroup	Evidence		LocalityID	Group
EvidenceKeyedByZone	Evidence	ZoneID		
OverallConfidence	Evidence		LocalityID	Group
AHC_RiverSections	Input	ScenarioID	LocalityID	
CC_ChannelConditionMatrix	Input			Row
CC_ChannelConditionReductionValues	Input			
CC_MatrixFloodReturnPeriod	Input			
ConditionWeights	Input		LocalityID	Group
Connections	Input		LocalityID	Group
EditFlags	Input			Group
FishSpecies	Input			Group
FP_FishPassageClasses	Input			ClassID
FP_FishPassage	Input	ScenarioID	LocalityID	Group
LHCNF_LarvalJuvenileHabitatConditonNoFlood	Input		LocalityID	Group, Version
Migration	Input		LocalityID	Group
RiverSections	Input		LocalityID	
SC_CatfishSubstrateConditionClasses	Input			ClassID
SC_CatfishSubstrateFlush	Input		LocalityID	Group
SC_SubstrateFlushClasses	Input			ClassID
SC_SubstrateFlushingCondition	Input		LocalityID	Group
SHCNF_SpawningHabitatConditionNoFlood	Input		LocalityID	Group, Version
WD_WoodyDebrisClasses	Input			ClassID
WT_WaterTemperatureClasses	Input			ClassID
DP_DryPeriod	InputPrefCurve		LocalityID	Group, Version, x
DR_RateOfFlowRiseDuration	InputPrefCurve		LocalityID	Group, Version, x

Table Name	Type	Key (Multiple)		
FD_FlowDuration	InputPrefCurve		LocalityID	Group, Version, x
FM_SpawningFloodMagnitude	InputPrefCurve		LocalityID	Group, Version, x
FPA_FlowPercentile(Adult)	InputPrefCurve		LocalityID	Group, Version, x
FPL_FlowPercentile(Larval)	InputPrefCurve		LocalityID	Group, Version, x
FPS_FlowPercentile(Spawning)	InputPrefCurve		LocalityID	Group, Version, x
FT_FlowTiming	InputPrefCurve		LocalityID	Group, Version, x
IA_InundationArea	InputPrefCurve		LocalityID	Group, Version, x
ID_InundationDuration	InputPrefCurve		LocalityID	Group, Version, x
RFL_RateOfFlowFall(Larval)	InputPrefCurve		LocalityID	Group, Version, x
RFS_RateOfFlowFall(Spawning)	InputPrefCurve		LocalityID	Group, Version, x
RR_RateOfFlowRiseThreshold	InputPrefCurve		LocalityID	Group
ST_SpawningTiming	InputPrefCurve		LocalityID	Group, Version, x
AHC_AdultHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	Group
DP_DryPeriodIndex	OutputIndex	ScenarioID	LocalityID	Group
DR_RateOfFlowRiseDurationIndex	OutputIndex	ScenarioID	LocalityID	Group
FD_FlowDurationIndex	OutputIndex	ScenarioID	LocalityID	Group
FHC_FishHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	Group
FM_SpawningFloodMagnitudeIndex	OutputIndex	ScenarioID	LocalityID	Group
FPA_FlowPercentile(Adult)Index	OutputIndex	ScenarioID	LocalityID	Group
FPL_FlowPercentile(Larval)Index	OutputIndex	ScenarioID	LocalityID	Group
FPS_FlowPercentile(Spawning)Index	OutputIndex	ScenarioID	LocalityID	Group
FP_FishPassageIndex	OutputIndex	ScenarioID	LocalityID	Group
FT_FlowTimingIndex	OutputIndex	ScenarioID	LocalityID	Group
IA_InundationAreaIndex	OutputIndex	ScenarioID	LocalityID	Group
ID_InundationDurationIndex	OutputIndex	ScenarioID	LocalityID	Group
LHCNF_LarvalHabitatconditonNoFloodIndex	OutputIndex	ScenarioID	LocalityID	Group
LHC_LarvalJuvenilehabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	Group
MF_MaintenanceFlowIndex	OutputIndex	ScenarioID	LocalityID	Group
RFL_RateOfFlowFall(Larval)Index	OutputIndex	ScenarioID	LocalityID	Group
RFS_RateOfFlowFall(Spawning)Index	OutputIndex	ScenarioID	LocalityID	Group
RHC_RecruitmentHabitatConditionIndex	OutputIndex	ScenarioID	LocalityID	Group
RR_RateOfFlowRiseIndex	OutputIndex	ScenarioID	LocalityID	Group
SC_SubstrateConditionIndex	OutputIndex	ScenarioId	LocalityID	Group
SHCNF_SpawningHabitatConditionNoFloodIndex	OutputIndex	ScenarioId	LocalityID	Group
SHC_SpawningHabitatConditionindex	OutputIndex	ScenarioId	LocalityID	Group
ST_SpawningTimingIndex	OutputIndex	ScenarioId	LocalityID	Group

Algal growth database (ALGAE.MDB) and tables

Table Name	Type	Key (multiple)		
EvidenceKeyedByZone	Evidence	ZoneID		
OverallConfidence	Evidence	ZoneID		
AlgaeAlertLevelCodes	Input			cellCount
AlgaeDescription	Input			AlgalID
Connections	Input		LocalityID	AlgalID
WeirPools	Input		LocalityID	
OverallIndex	OutputIndex	ScenarioID	LocalityID	AlgalID
CellCount	Output	ScenarioID	LocalityID	AlgalID
R	Output	ScenarioID	LocalityID	AlgalID
Stratification	Output	ScenarioID	LocalityID	AlgalID

Climate database (CLIMATE.MDB) and tables

Table Name	Type	Key (Multiple)		
PotentialET	Input	ZoneID		Statistic
Temperature	Input		LocalityID	Statistic
Windspeed	Input		LocalityID	Statistic

Table Name	Type	Key (Multiple)	
Turbidity	Input	LocalityID	Statistic
RelativeHumidity	Input	LocalityID	Statistic

Flows database (FLOWS.MDB) and tables

Table name	Type	Key (Multiple)		
Flows	Input	ScenarioID	FlowID	
StageHeight	Input		FlowID	Flow

Register Control database (REGISTER.MDB) and tables

Table Name	Type	Key
Assessments (not used MFAT)	Input	
AssessmentTypes (not used MFAT)	Input	
ComparisonRanges (Not used MFAT)	Input	
ConfidenceLevels	Input	ConfidenceLevel
Localities	Input	LocalityID
LocalityModels	Input	LocalityType
Scenarios	Input	ScenarioID
Settings (not used MFAT)	Input	

Integration assessment weightings database (MIA.MDB) and tables

Table Name	Type	Key (multiple)		
EvidenceForZones	Input			TableName
EvidenceKeyedByZone	Input	ZoneID		TableName, Version
EvidenceKeyedByZoneModel	Input	ZoneID		TableName, Assessment
LocalityModelWeightings	Input		LocalityID	Model
Settings (not used MFAT)	Input			
ZoneModelWeightings	Input	ZoneID		Model
Zones	Input	ZoneID		

Water quality database (WATQUAL.MDB) and tables

Table Name	Type	Key (multiple)		
MouthOpeningIndex	Input	ZoneID	ScenarioID	
Salinity	Input		ScenarioID	ID

Relationships between databases

Model	Reads	Writes to
Floodplain Hydrology	REGISTER MIA FLOWS VOLUMES	VOLUMES
Algal Bloom	REGISTER MIA CLIMATE FLOWS ALGAE	CLIMATE ALGAE
Native Fish Habitat Condition	REGISTER MIA FLOWS FISHHAB	FISHHAB (MIA if changing weights across localities)
Waterbird Habitat Condition	REGISTER MIA VOLUMES BIRDHAB	BIRDHAB (MIA if changing weights across localities)

Model	Reads	Writes to
Floodplain Vegetation Habitat Condition	REGISTER MIA VOLUMES FVEGHAB	FVEGHAB (MIA if changing weights across localities)
Wetland Vegetation Habitat Condition	REGISTER MIA VOLUMES WVEGHAB	WVEGHAB (MIA if changing weights across localities)
Explore	REGISTER MIA FLOWS VOLUMES ALGAE BIRDHAB WVEGHAB FVEGHAB FISHHAB WATQUAL	

The waterbirds and vegetation models require the VOLUMES database to be populated. This database can be very large.

Appendix C MFAT CONCEPTUAL MAPS

This Appendix contains the set of conceptual diagrams which are also distributed with the MFAT. They detail the logic within the models and the linkages to databases. The diagrams have been prepared by B Rennie, CRC FE, and are best reproduced in colour.

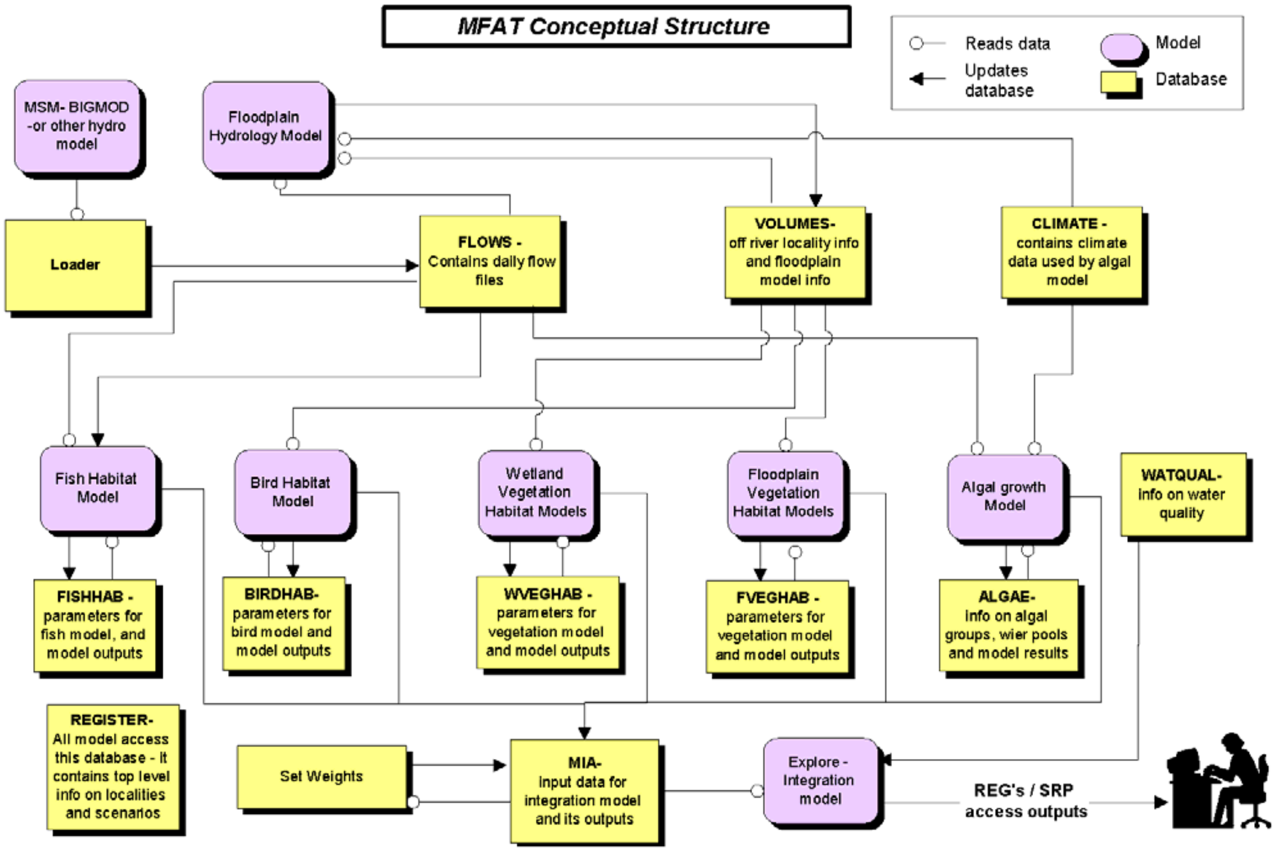

Figure C.1 MFAT conceptual linkages map

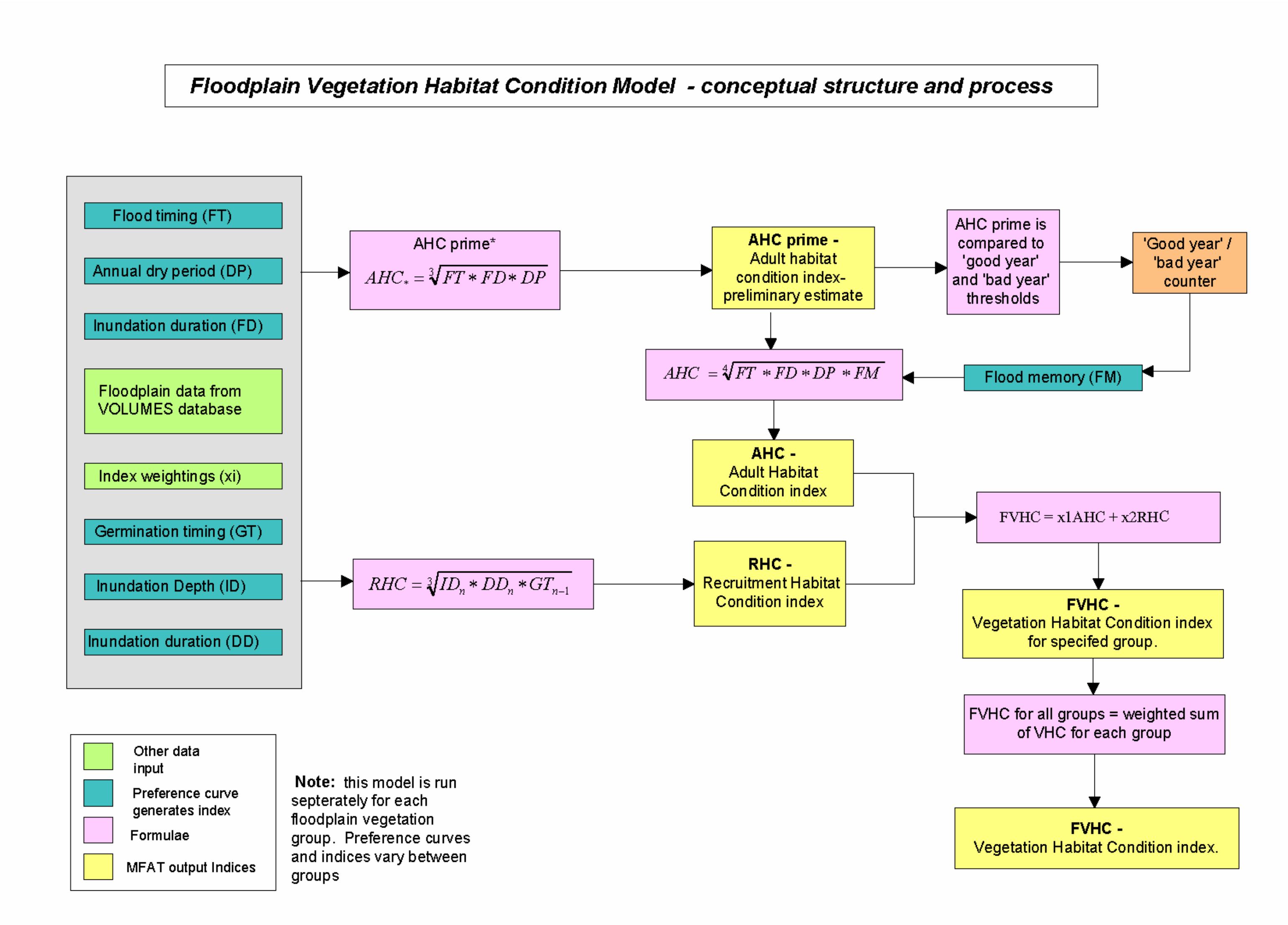

Figure C.2 Floodplain vegetation habitat assessment model conceptual map

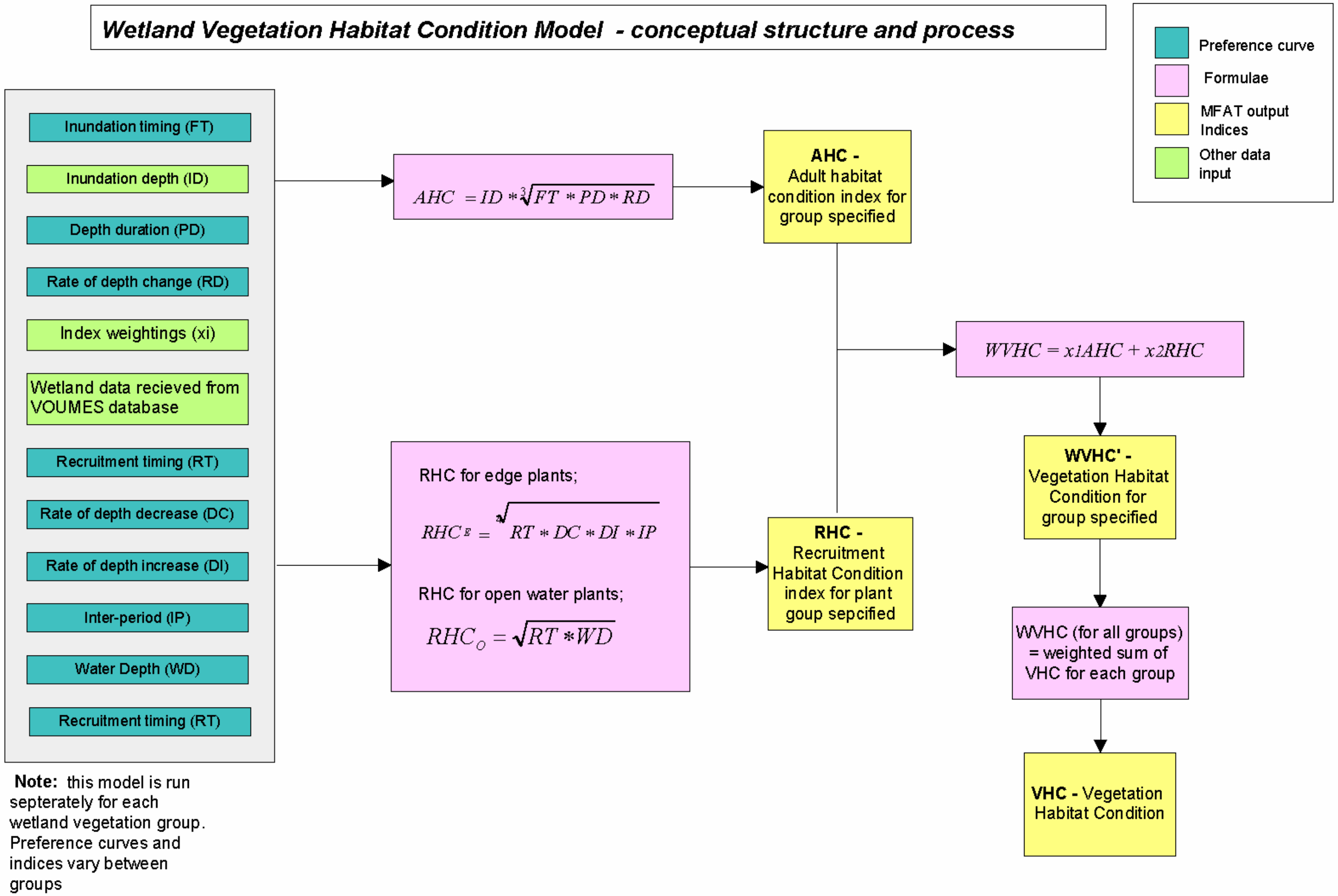

Figure C.3 Wetland vegetation habitat assessment model conceptual map

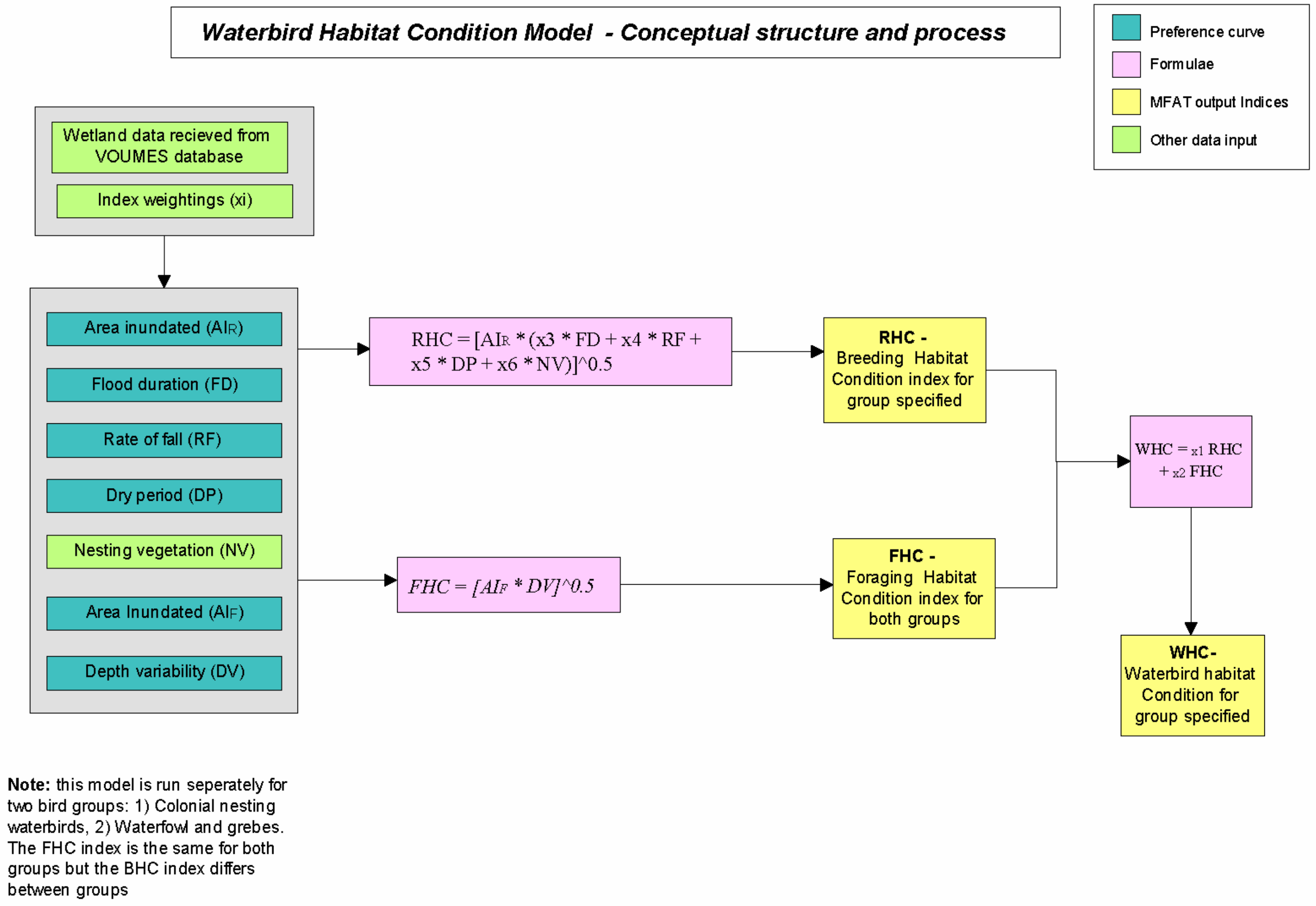

Figure C.4 Waterbird habitat assessment model conceptual map

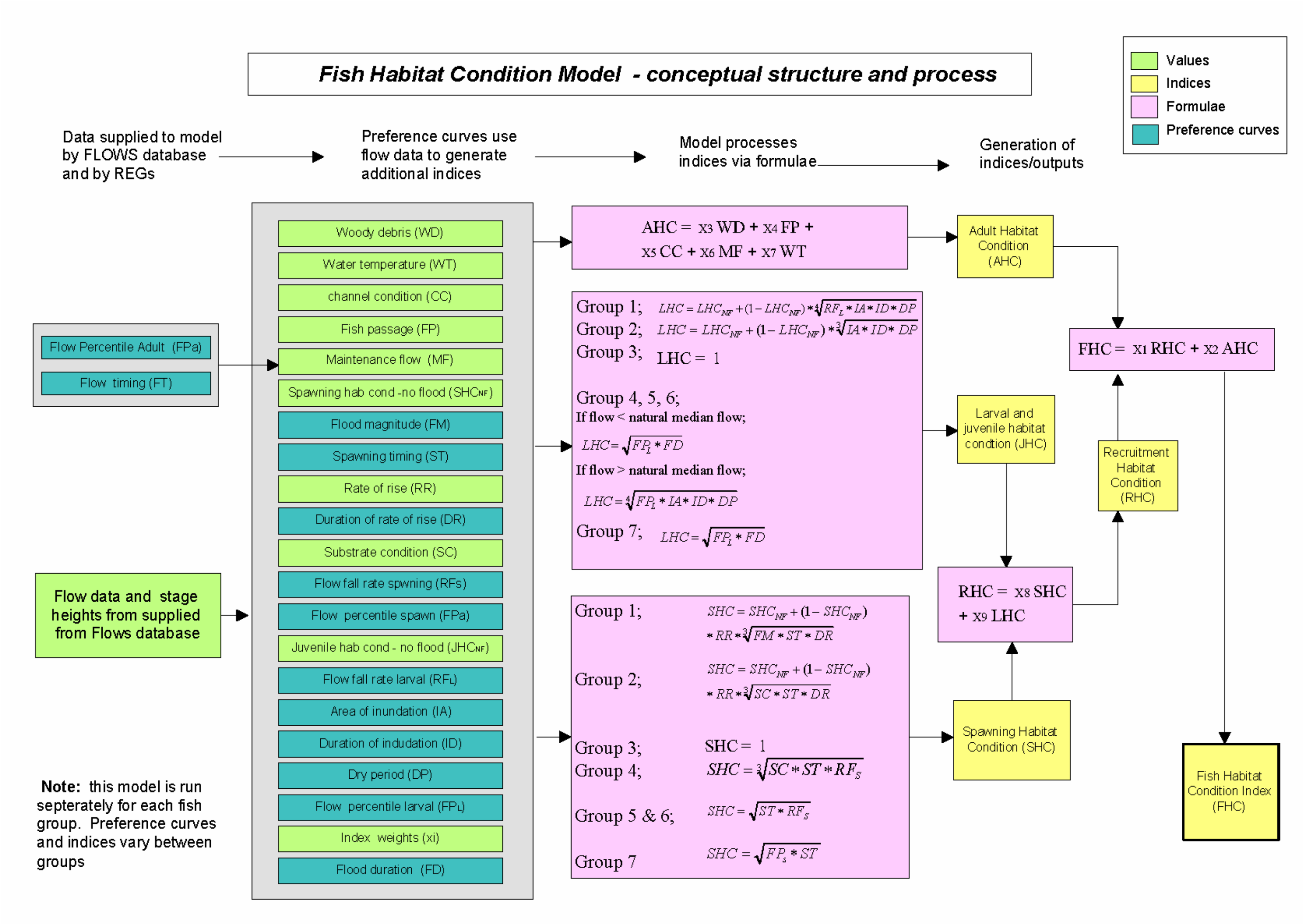

Figure C.5 Native fish habitat assessment model conceptual map

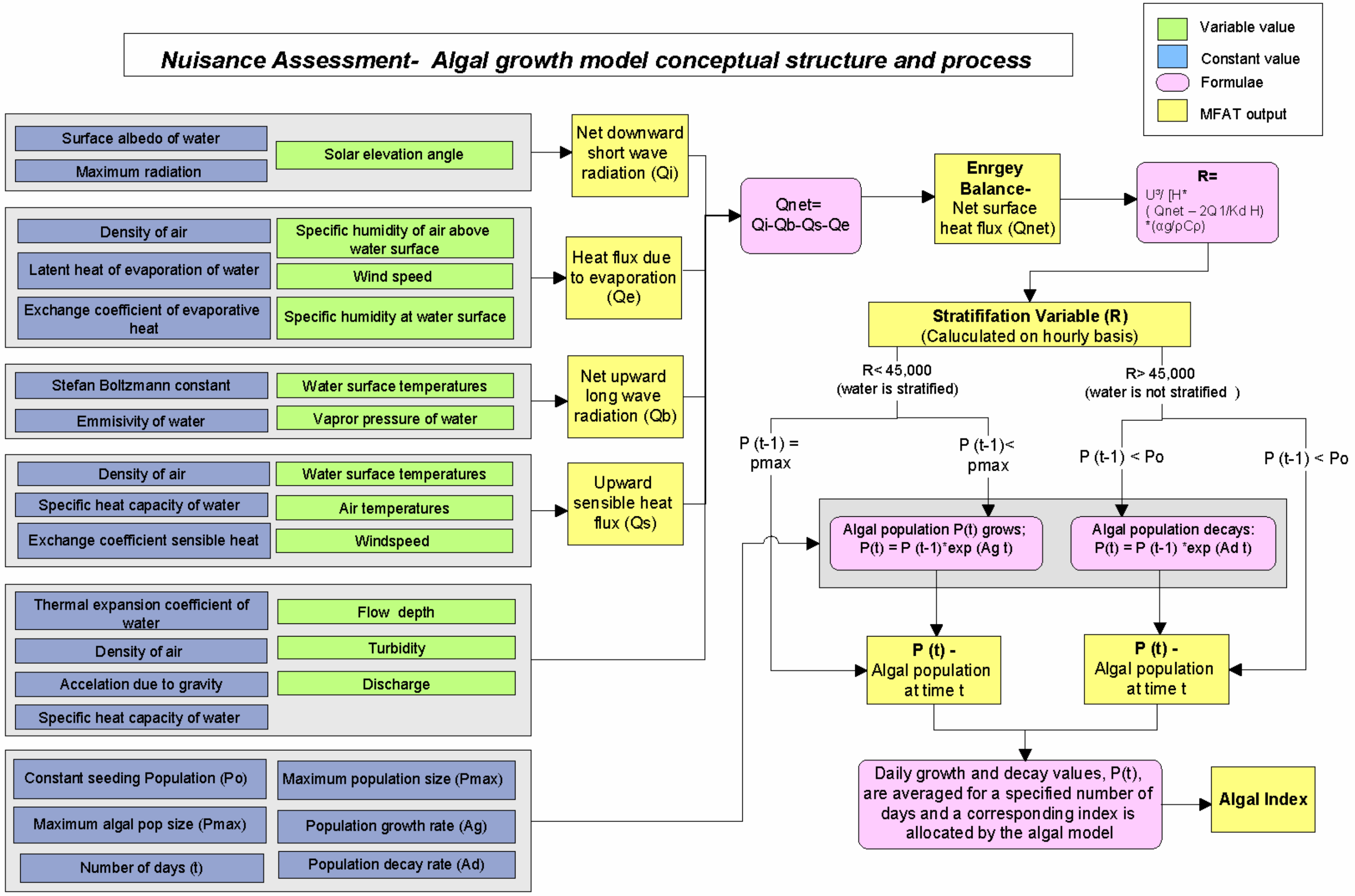

Figure C.6 Algal growth model conceptual map