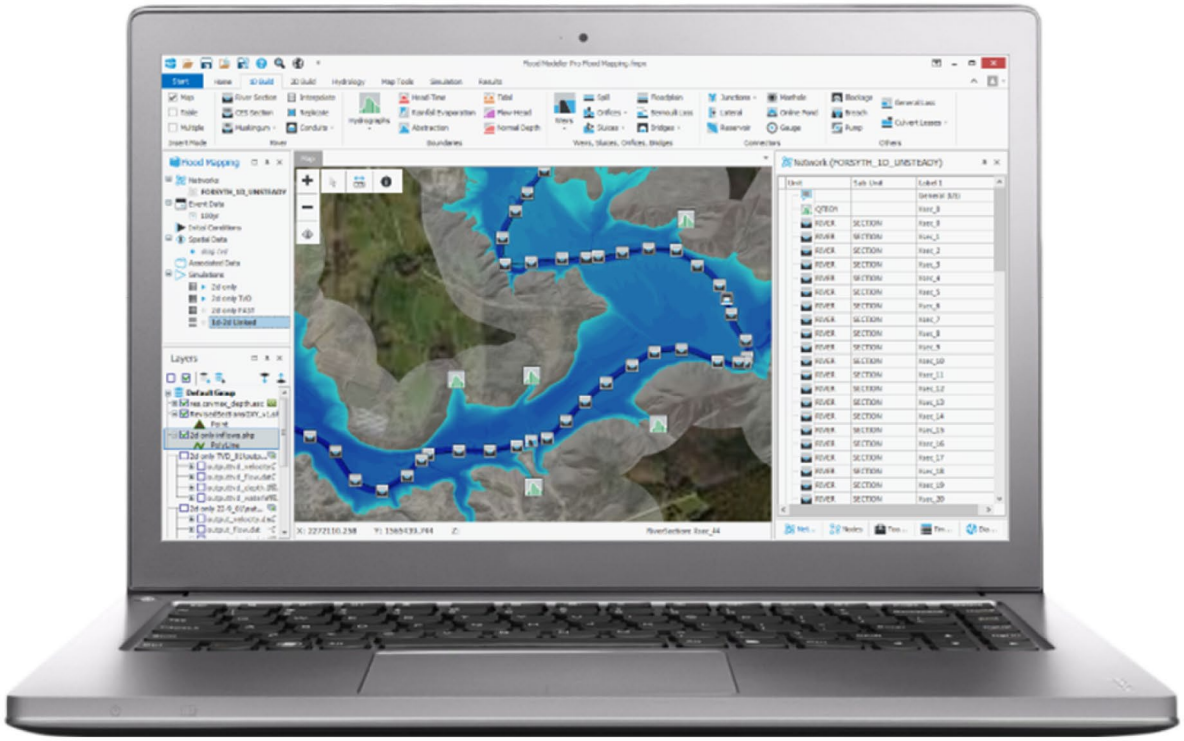
Release notes

Flood Modeller

Version 4.6



www.floodmodeller.com

Jacobs

Flood Modeller Release notes

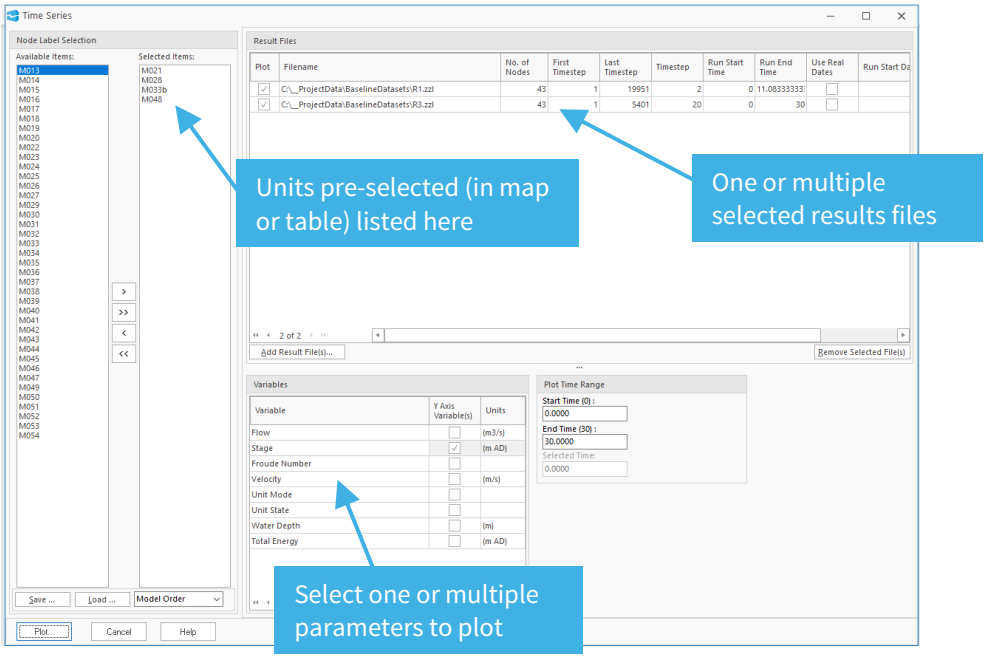
Flood Modeller v4.6 introduces a range of new functions (compared to v4.5) and addresses a number of issues identified in previous versions. This document contains the following sections:

1. Flood Modeller v4.6 – changes and enhancements

1.1 Changes to Flood Modeller user interface in v4.6

The following enhancements were made to the Flood Modeller interface for v4.6:

(a) Flood Modeller 1D results plotting has been enhanced to allow the selection of multiple results files in a single operation. To achieve this the design of the pop-up window for detailing a plot has been revised, as shown below:



The enhanced plot definition window applies to all 1D plot types, i.e. time series, long sections, cross sections and XY plots.

(b) Complimentary modifications have also been made to the resulting 1D plots:

- Legend format has been changed to enable more information to be displayed
- Data series can be turned off/on using checkboxes in legend
- Right-click menu provides link back to plot definition window to enable additional modifications (Add/Edit/Remove series)
- Plot editing also allows for the addition of cal/cus calibration files

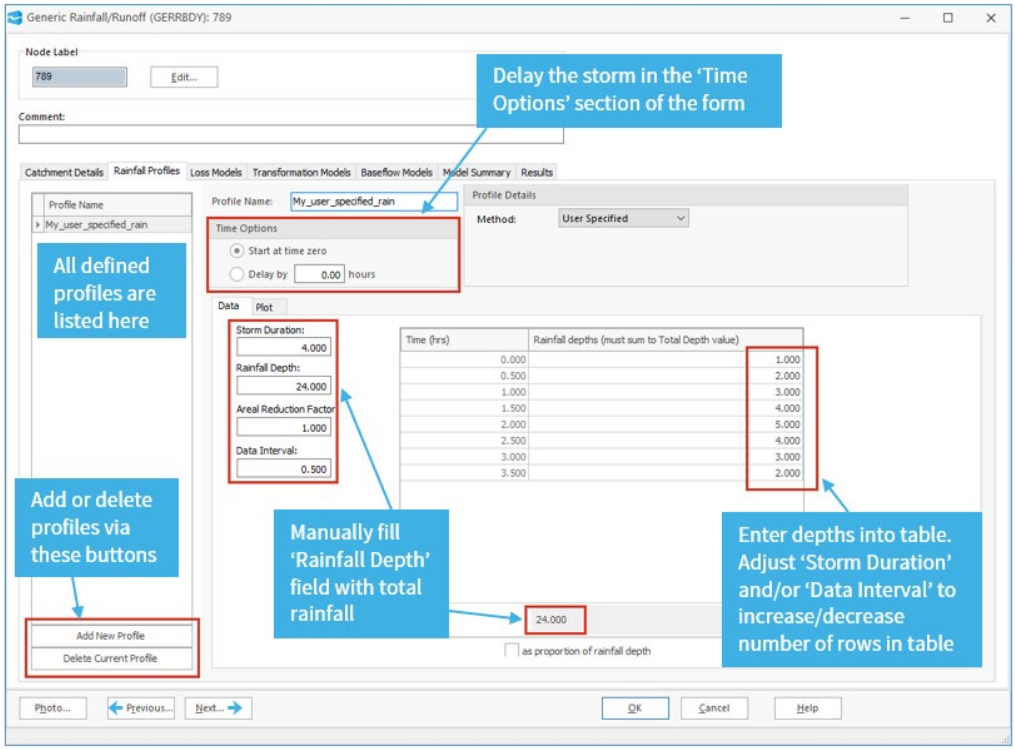
(c) A revised licencing model has been implemented in the user interface (as well as in the 1D and 2D solvers). Checks are now performed prior to the following actions in the user interface:

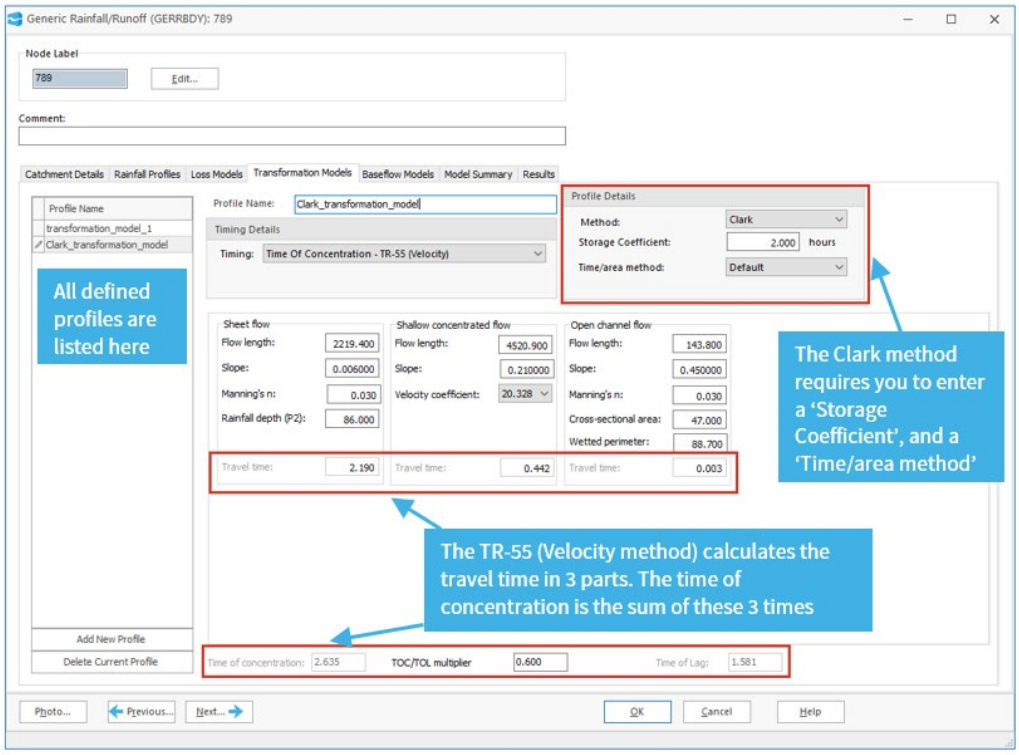
- When a new 1D network is loaded in the project panel
- When a loaded 1D network is edited and saved
- When a user starts a 1D, 2D or 1D-2D linked simulation

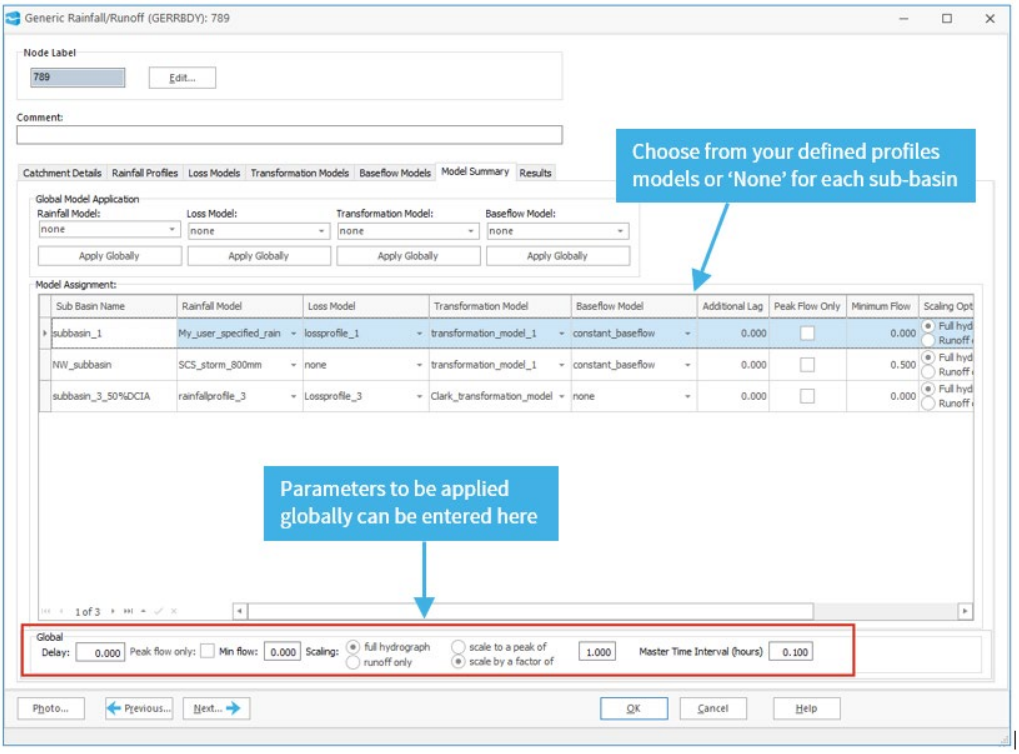
The 1D model specified in the user's action is compared against the criteria for the user's available licence. Licence options in v4.6 will be Free, Standard and Professional. If the node count of the specified 1D network exceeds the limit associated to the user's available licence, then the action is aborted and an appropriate message displayed. Note that this means that models exceeding the limit set for your licence will no longer load for the purposes of model and result reviewing.

(d) The generic rainfall runoff boundary has been significantly enhanced. It now offers multiple options for each hydrological component, i.e. rainfall, infiltration, transformation, unit hydrograph and baseflow. Furthermore, you can divide a catchment into multiple sub-catchments and define different methods to simulate each. The resulting flows are then combined to produce an overall net flow output, which can be incorporated into a 1D or 2D model as boundary data.

The options offered for each hydrological component are globally recognised methods (see user guide for references). Thus, this boundary provides a useful alternative to the more UK specific hydrological boundaries already included in Flood Modeller.



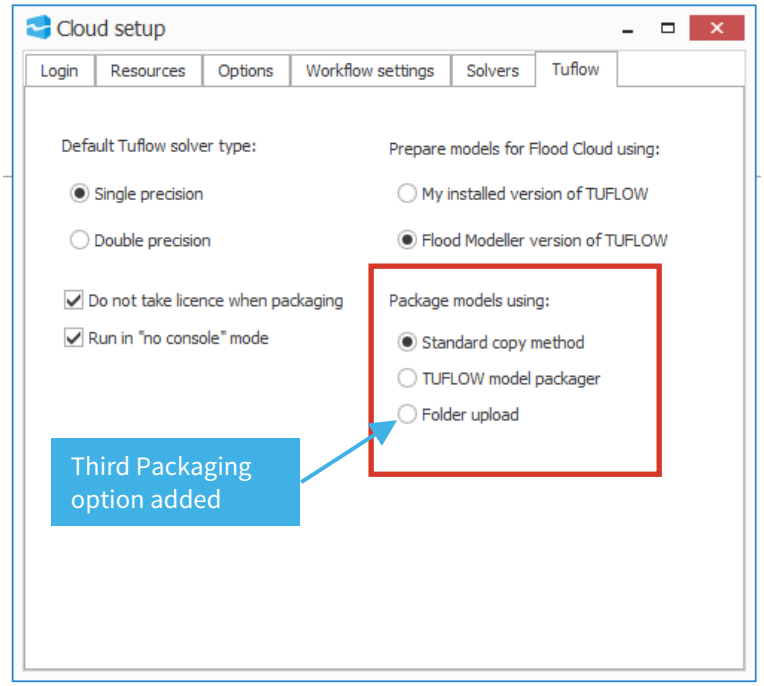




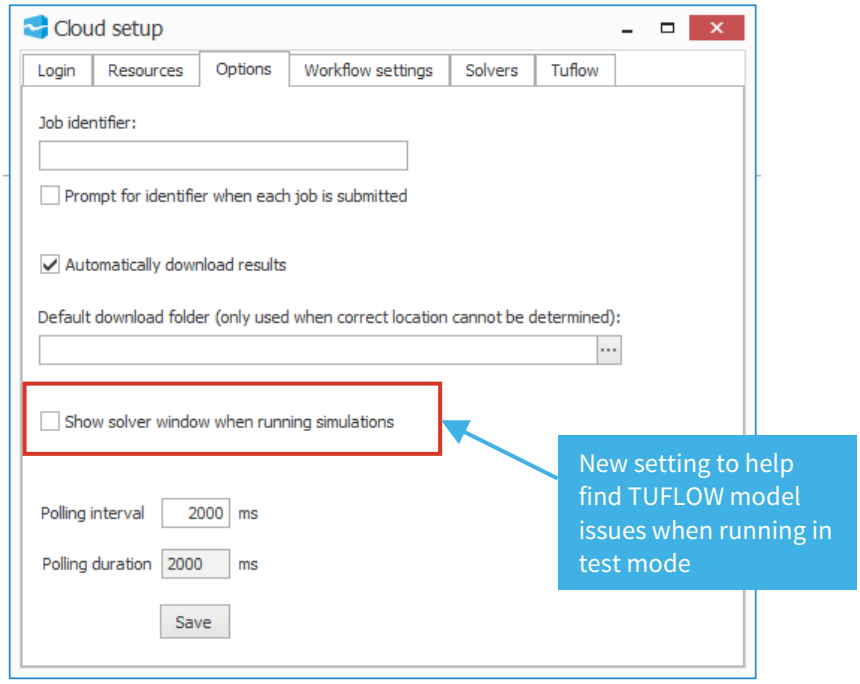
(e) Previously, if you generated a 1D data plot on a secondary screen and then reverted to a single screen display, then subsequent plots would be created "off screen". This would require a manual edit of the formsed.ini settings file. Now the Flood Modeller interface checks your setup and positions new plot windows so they should always be immediately visible.

(f) Flood Cloud has been updated to be compatible with TUFLOW 2018-03-AE and Flood Modeller v4.6 (and HEC-RAS is v5.07 – unchanged from previous version).

(g) A third option is added for packaging TUFLOW models (i.e. TUFLOW only models and TUFLOW linked models; to Flood Modeller 1D and/or ESTRY). This option is independent from TUFLOW in-built packaging functions. It should provide greater reliability (and in some cases work faster) than these. However, note that it requires a particular model file/folder structure to be set up prior to starting your simulations (see user guide for details). This new option is not set as the default option but can be selected in the Flood Cloud settings (TUFLOW tab).



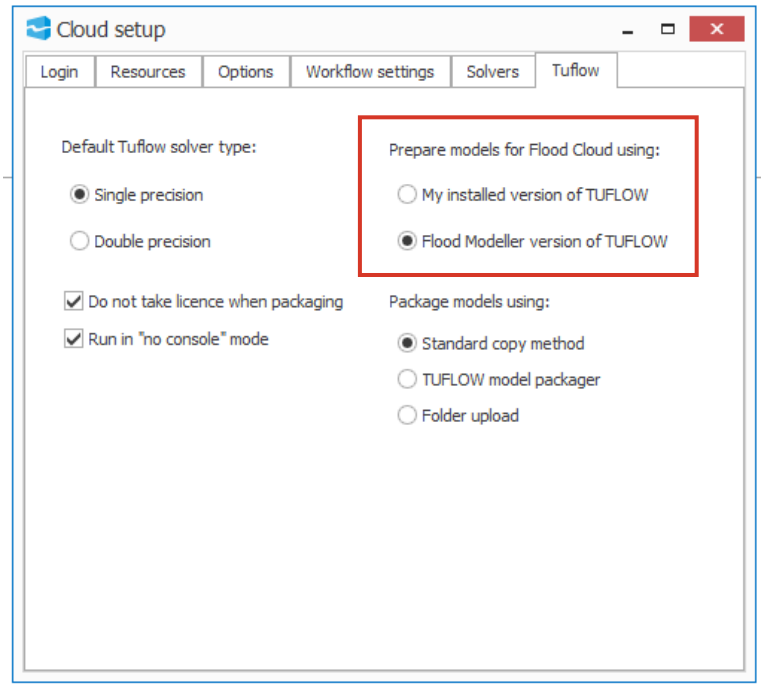
(h) An option has been added to allow TUFLOW models to run displaying the TUFLOW native progress window. Note this option only applies when running models locally in test mode. TUFLOW models have been known to "hang" waiting for a user interaction, the prompt for which is only displayed in the TUFLOW native progress window and not in the Flood Modeller general simulation progress window. Thus, the option to display this window in test mode enables users to identify more issues prior to uploading to Flood Cloud (and 'wasting' credits).



The default setting in Flood Cloud is to not display the TUFLOW progress window. This setting can be changed either in the Flood Cloud settings window (Options tab) or in the Flood Modeller main interface, in General Settings.

Note that activating this setting will also configure your linked test mode simulations to display a separate progress window for the Flood Modeller 1D component of your model.

(i) Packaging TUFLOW models, ready for cloud upload, can utilise the included TUFLOW packager or can be set to use your local TUFLOW installation (if required and if this is a different version). The latter will require the appropriate TUFLOW software to be present locally. The setting for this is accessed on the Flood Cloud settings window (TUFLOW tab).



Note that this setting does not apply if you choose to package your TUFLOW models using the Folder upload method.

(j) The TUFLOW packager included in the Flood Cloud installation has also been updated (to TUFLOW 2018-03-AE).

(k) Flood Cloud has been enhanced to make it compatible with a wider range of TUFLOW (and HEC-RAS and Flood Modeller) model scenarios, e.g. capturing additional input files referenced by the model.

(l) When using the TabularCSV tool to extract time series data from your 1D model, the tool previously would open with the active results file pre-loaded. The tool now also looks for a network file (dat file) with a matching name (in the matching folder) and if this is present then this will also be automatically pre-loaded. This aims to make using the tool more efficient to use.

(m) Flood forecasting functionality enhanced so that the "Export to FEWS" option creates all model folders expected by the FEWS system, even if that means some folders are blank (previously only folders containing data were created).

1.1.2 User Interface bug fixes

(a) The issue with adding new rows to the Control table of a 1D abstraction unit has been fixed. It is now possible to add lines to the control table (and without an error message appearing).

(b) Multiple model domains can be defined in the 2D model interface. Previously, the order that these domains were stored could be random, which could make it difficult to identify which results corresponded to which domain. Now the domain order is maintained throughout the 2D model process, so it is clear which results correspond to which 2D domain.

(c) The 2D model interface has been corrected to resolve an issue with 2D linked SWMM models. A correct mass balance filename is set in the 2D model file (referencing the SWMM inp filename) irrespective of how the linked SWMM model is specified in the 2D model interface.

(d) When exiting from Flood Modeller or removing a 1D network from the Project Panel the interface should now only prompt to save changes once (previously the same prompt would be repeated, even after saving on the first prompt).

(e) Right-click option on map view to save the view as a georeferenced image file has been corrected so the image aspect ratio is maintained.

(f) When removing a modified 1D network file (dat file) from your project panel Flood Modeller now only prompts once to save changes (rather than the same prompt twice).

(g) Checks added when removing either a lateral node from a river unit or a river node from a lateral unit to look for corresponding node references (in the associated river and lateral units). Flood Modeller will then automatically remove the unwanted node references from lateral and associated river units as well as from the initial conditions. This corrects errors seen when running model simulations with a network in which river or lateral units have been modified.

(h) Catastrophic error now prevented when saving a network for which the underlying file is read only.

(i) "Ctrl + N" option removed from shortcuts available in network table right-click menu (where it was used for editing node labels). This shortcut is already in use for accessing the New Project function.

(j) Fixed issue with HEC-RAS section conversion caused when the HEC-RAS cross-section chainage starts at a negative value.

(k) Fixed export to kml issue - by referencing newer, 64-bit Access drivers (which are included in installer).

(l) Catalogue tool: Fixed problem where newly added simulation was not added properly if the extension was capitalised

(m) Fixed catastrophic failure problem that would occur when loading a (partial) model which currently ended in an interpolate unit (i.e. not a valid model).

(n) Fixed error when running 1D-2D linked simulation where the mass error and combined mass error were displayed on the same runtime plot

(o) Fix for HEC-RAS test mode in Flood Cloud - 1200 time was being wrongly converted to 0000

(p) Fixed problem in Flood Cloud where the current processing stage was not shown in the progress bar for HEC-RAS simulations

(q) Flood Cloud problem fixed when optimising large files - tool was falling over as it was looking for a case sensitive filename match.

(r) Fixed problem in Flood Cloud where non-converged count and combined mass error, were sometimes not shown in the grid.

(s) Revised display in Flood Cloud History form to reduce 7 decimal places displayed for Duration values.

(t) Web links included in user interface have been updated to match revised Flood Modeller website links.

1.2 Enhancements to the 1D and 2D calculation engines implemented in v4.6

The following sections detail changes and enhancements made to Flood Modeller 1D and 2D solvers.

All solvers in the v4.6 release have been compiled using the latest Intel Fortran and C++ compilers. In previous versions of Flood Modeller, the solvers were compiled with earlier versions of these compilers. It is possible that the upgrade of the compilers may lead to slightly different results compared to simulations run using earlier versions of the software (using the same settings). This will usually equate to differences measured in fractions of a mm, however in some cases (where a model is particularly sensitive to small changes) bigger differences may be seen.

1.2.1 1D Solver enhancements

(a) Hydrology module has been significantly enhanced to encompass new calculations that are part of the revised generic rainfall runoff boundary unit. A new method of transformation, using a Clark unit hydrograph with a default time-area method has been added. The timing details for the transformation methods have also been added to; the Kerby, Kirpich and Kerby/Kerpich combined methodologies have been added to the time of concentration options, and one can now choose to enter a time of lag rather than a time of concentration, either user specified or via the Snyder method.

(b) The hydrology calculation enhancements have also led to changes in the data written out to the hydrology output file (zzh file). However, backward compatibility to the previous zzh format has also been maintained.

(c) Fixed errors in calculating top width and default top slot height for rectangular conduit top slots

(d) Issues with the steady direct and steady time stepping 1D solver run modes when working in US units have been addressed:

- Steady (Pseudo) time stepping does now convert all output (as appropriate) to US units for steady-state output (*.zzs) file
- Writing to steady-state output (*.zzs) file now does not convert null flows, velocities or stage values to ft/ft^3
- "Invalid density" warning - now outputs in correct units

(e) A revised licencing model has been implemented in the 1D solver. The pre-simulation checks the user's available licence and compares the specified 1D model against the criteria for Free, Standard and Professional. It then acts accordingly on the result of this test and writes the appropriate licence information to the simulation log file (i.e. as with previous versions).

(f) TUFLOW Link – if inconsistent timesteps (between Flood Modeller's 1D solver and TUFLOW) are detected, these are now reset by Flood Modeller *prior* to the call to TUFLOW, thus ensuring these adjustments persist in TUFLOW too

(g) TUFLOW Link updated to call solver_s4b, etc. from new TUFLOW dll (not hpc_s4c). No affect on current operation, but this change allows potential linking to Quadtree in future.

(h) Fixed issue whereby irregular conduit area property was being incorrectly calculated (with large [e.g. default] sconmx – Preissmann slot height – value), sometimes leading to invalid stage outputs.

(i) Version number of Flood Modeller 1D was truncated when linked to Flood Modeller 2D - causing this number to be incorrect when output to log files (and therefore misleading information in the Catalogue)

(j) Issue fixed related to the Direct Method. Downstream QH and NCD boundaries were not receiving (initial) flow value, thus not able to provide correct/sensible water stage.

(k) Wind data was failing to read right-aligned data fields, e.g. would not pick up selected coordinate source to obtain correct orientation; fixed.

(l) Linked SWMM models were not closing SWMM correctly, leading to issues with SWMM result output.

(m) If (additional) "Convergence Information" (Diagnostics tab) was selected for a console ("NotWin") application simulation, then outputting this would cause fatal write error; fixed.

1.2.2 2D Solver enhancements

(a) Topographic modifications made within a Q-link shapefile are no longer ignored (previously they were only applied if the existing cell contained null elevation value).

(b) A revised licencing model has been implemented in the 2D solver. The pre-simulation checks the user's available licence and compares the specified 2D model against the criteria for Free, Standard and Professional. It then acts accordingly on the result of this test and writes the appropriate licence information to the simulation log file (i.e. as with previous versions).

(c) Polyline shapefiles containing only one attribute were causing "polyline-point" (Z-line) topographic modifications to be ignored: fixed.

(d) Curve number (CN) or Green-Ampt (GA) infiltration attribute is now read in correctly from the simulation (*.xml) file.

(e) When the "*add*" attribute was being used for topographic modifications AND attributes *height*, *height1* and *height2* were all present in the shapefile, the outcome was unpredictable. Hirearchy now affirmed as using *height* in preference to *height1* and *height2*. Also, clarity on which attribute is being used now output to the log file.

(f) Information (log file) message output when topographic modifications are being used from Link Lines' height1 & height2 attributes (and when from the height attribute, such output is moved to a more relevant [later] section in the log file).

2. Flood Modeller v4.5 – changes and enhancements

2.1 Changes to Flood Modeller user interface in v4.5

The following enhancements were made to the Flood Modeller interface for v4.5:

(a) Flood Modeller user interface has now been compiled using only 64-bit components. The main advantage of this is it enables the interface to access more memory (the previous 32-bit interface restricted loadable file sizes to an approximate 1GB, irrespective of available computer memory). Thus, it should now be possible to load larger GIS datasets into the map view. Note that load speeds will likely be unchanged, so loading larger datasets will take time.

(b) 2D model interface has been updated to be compatible with changes made to the 2D solver. Thus, you can select to automatically generate maximum flood extents as ASCII or GeoTIFF format grids during a simulation. The default setting is to always output maxima data as ASCII grids for each domain within your 2D model. This can be changed (on a domain by domain basis) on the Outputs sub-tab of the 2D model interface.

In addition, there are now two options for writing out check grids during a 2D simulation. These can still be written as ASCII raster grids (the default setting), but now can also be written to GeoTIFF format. This selection is also made on the Outputs sub-tab of the 2D simulation interface (on a domain by domain basis). Note that the default option does not write anything to the underlying 2D model XML file (also there is a third option which is to untick the check grid box and not write out this diagnostic information).

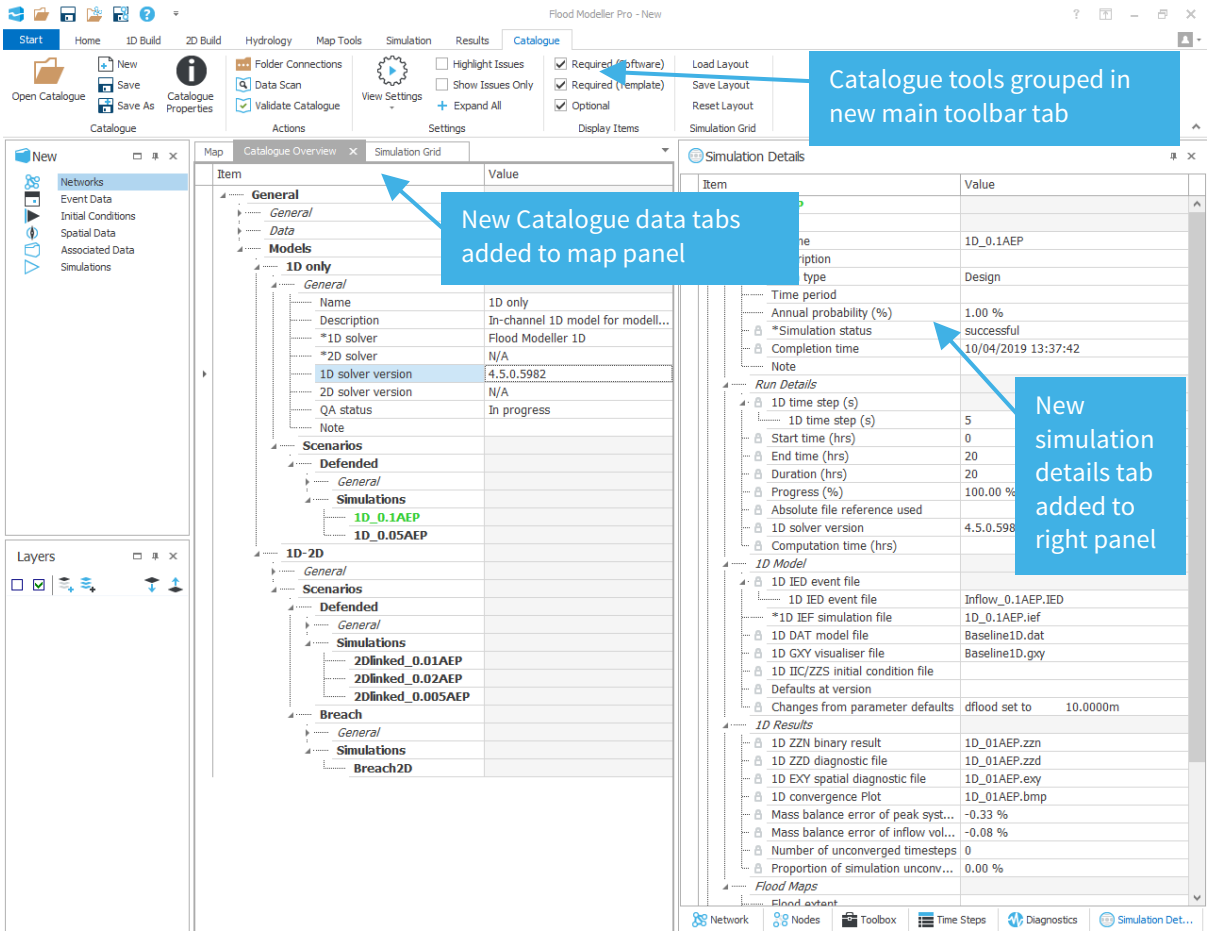
(c) New Project Catalogue Tool providing enhanced project management functionality to help organise modelling (Flood Modeller and/or TUFLOW) associated to a project. It incorporates standardised templates to guide the user to collect all required data associated to a project. The key benefits of the tool are:

- Automatically populates most simulation input and output data

- Easier to find stuff (i.e. inputs, run parameters, results)
- Easier to monitor modelling progress
- Easier to move files to a new location
- Easier to check that if all expected files are received

The data collected and catalogued by the tool includes:

- Data to be utilised as model inputs, e.g. DTM/DEM grids, topographic shapefiles, river surveys, gauge time series records, hydrological parameters
- Model files, e.g. Flood Modeller 1D networks (dat), events (ied) and simulations (ief) and/or TUFLOW control files (tcf), boundary files (tbc), geometry files (tgc), etc.
- Model results, both direct, i.e. raw outputs such as zzn/zzl or xmdf, and indirect, e.g. maximum flood extent outlines
- Reports and other miscellaneous files associated to the project, e.g. calculation spreadsheets, email records, etc



The Catalogue tab of the main toolbar includes tools to automatically scan your project to populate the metadata fields specified in the catalogue data template and then validate your project catalogue against the data requirements defined in the selected catalogue template.

Note: This initial version of the Catalogue Tool is considered a beta version. All included functions are fully working, but they are a subset of the planned functionality for the final version of the tool. It is envisaged that different users will want different things from the Catalogue Tool. We therefore thought it beneficial to release this initial beta version and then gauge reaction and feedback from users. This can then help guide the development of the final version to best meet the needs of our users.

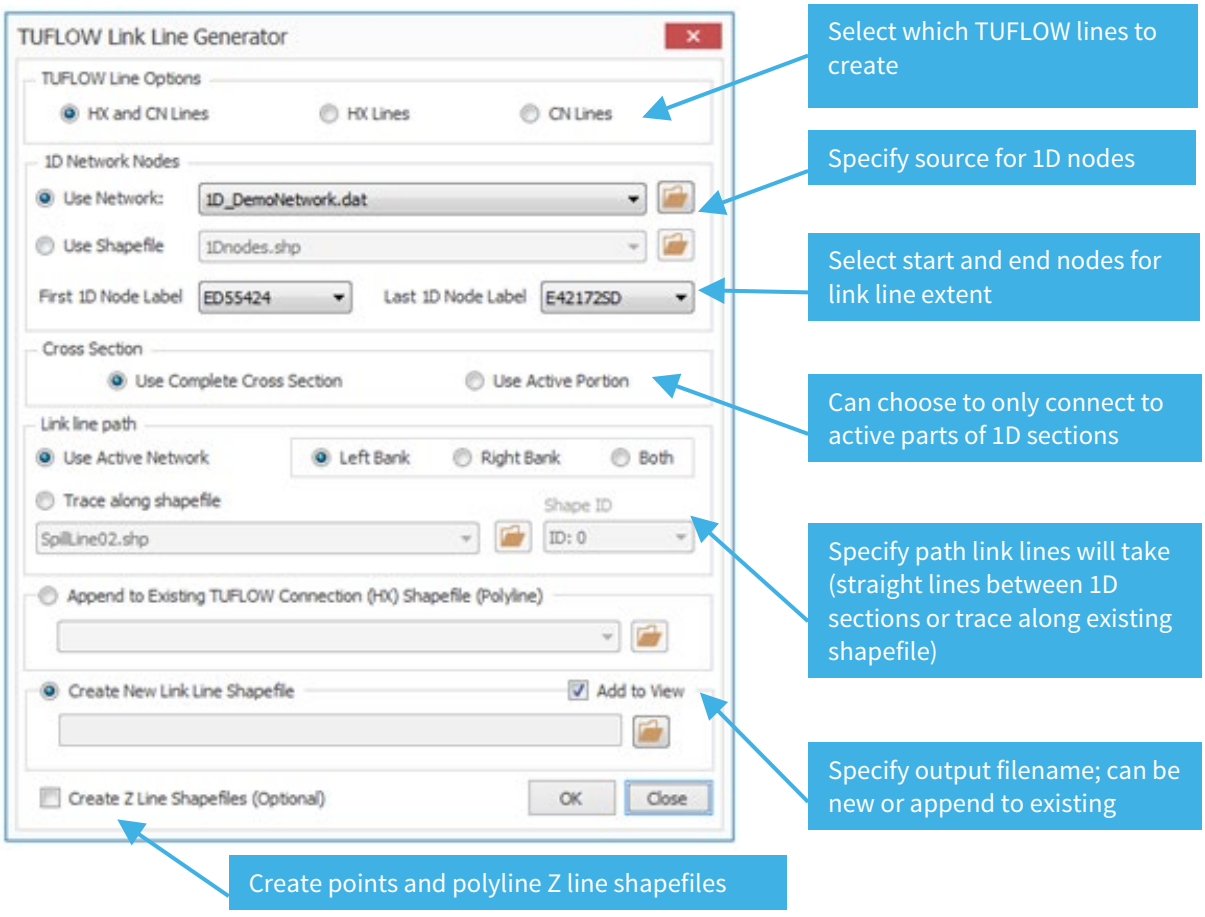
(d) New type of bridge unit can now be selected from the interface toolbar to be incorporated into 1D networks. The new bridge unit aims to improve the calculation capabilities of the software concerning the flow through bridges where the dominant cause of losses is the friction from piers. It utilises the empirical equation derived by Yarnell (1934). The addition of this unit provides a new option for modelling a bridge, in particular where low flow is more frequent.

(e) A new asymmetric conduit unit has been added to the 1D suite of unit types. The property window for the asymmetric conduit enables entry of an irregular channel shape. It also provides a choice of roughness coefficient; Mannings or Colebrook-White.

(f) The link line generator tool has been enhanced to provide multiple options for creating link lines (defining links in a 1D-2D linked model). In v4.5 the user can now:

- Use the active network or a point shapefile to define the start and end points of link lines and the 1D node references.
- Link location can now be defined by joining end points of 1D cross sections (these can be end of full sections or end of active portions only). Alternatively, tool can trace link lines along a specified polyline shapefile or polygon (active area) shapefile (previously only tracing along a polygon was possible).
- Link line elevations can be taken from an underlying DEM (ASCII raster grid) or from the section end point elevations of the active 1D network.

(g) A new TUFLOW Link tool has been added to the 2D build tab of the main Toolbar. This provides similar functionality to the 1D-2D link line tool, creating new polyline shapefiles containing TUFLOW HX and CN lines (used for the dynamic linking of TUFLOW 2D models (Classic or HPC) and Flood Modeller 1D networks). This tool provides a more automated alternative to manually drawing TUFLOW HX and CN lines using the shapefile editor (with the option of utilising snapping to existing features).

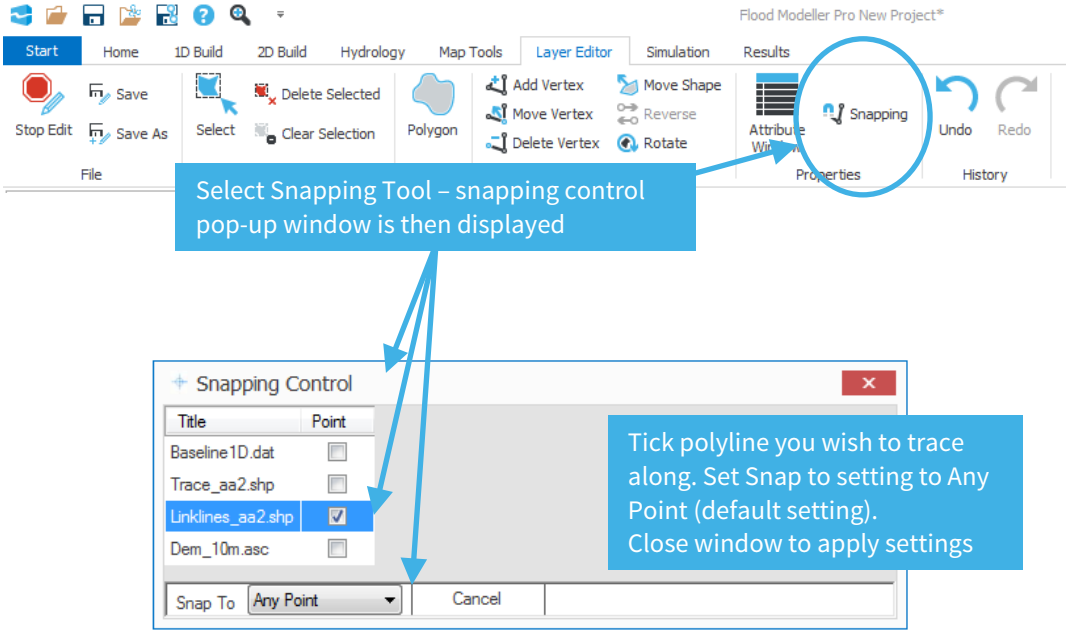


(h) 2D active area draw tool has new option to trace along a specified polyline shapefile (to form part of the overall active area).

If you have a (high) bank line or 1D-2D link lines already defined, then you can quickly trace your active area along these lines in a single operation (rather than separate clicks snapping to one point at a time) to extend your area over every point along the line. The tracing procedure is as follows:

- Ensure the polyline shapefile you wish to trace along is loaded in your map view and then start drawing a new active area.
- In the Layer Editor tab of the main Toolbar, select the snapping control. In the pop-up window that is then displayed, select to snap to the polyline shapefile you will be tracing along – tick the box next to the appropriate file and select to snap to any point on the line (the default option).

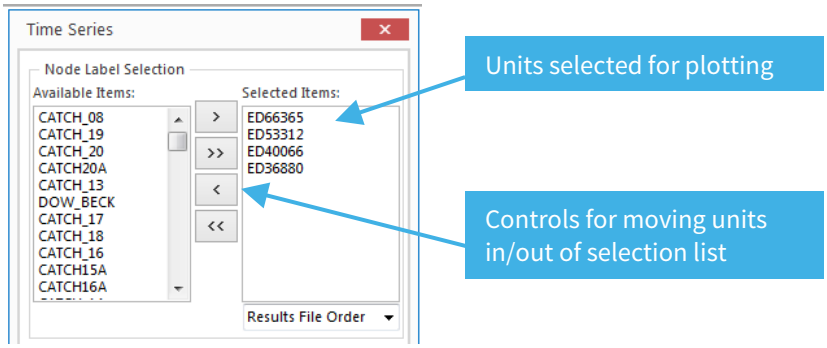
  It is recommended that when tracing you should only have snapping defined for the polyline selected to trace along and no additional files.



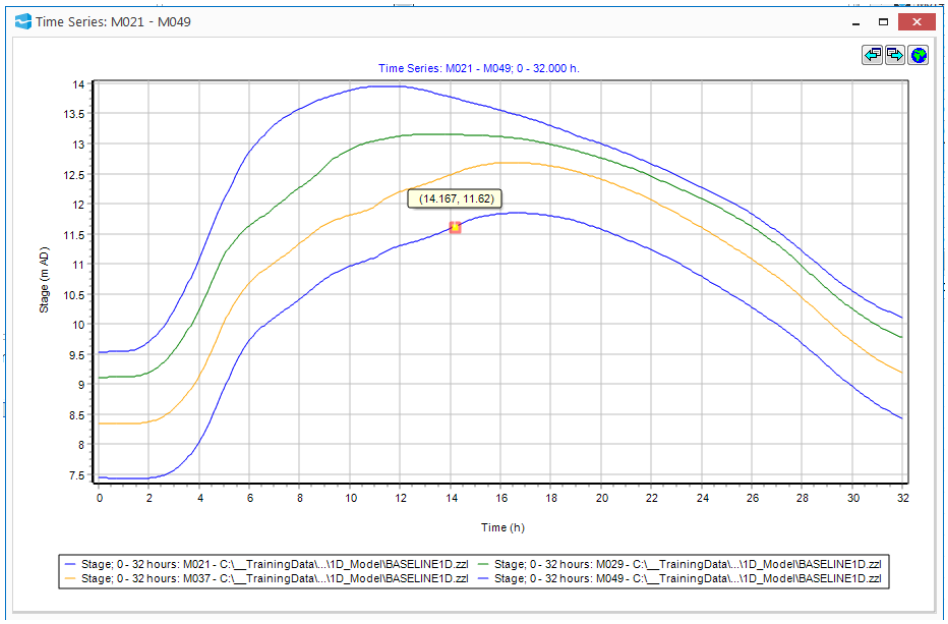
- Close the pop-up window to apply the snapping setting.
- Click on the Draw Polygon button in the Layer Editor to start drawing a new active area. Move the mouse cursor (which should change to a pen icon) close to the point where you wish to start tracing on your polyline. The snapped point should be shown with a dotted line rectangle surrounding it. Click the left mouse button to start drawing from this point.
- With the Shift key depressed, move the cursor to where you want to trace to on the polyline. When the correct point is displayed with the “snapped to” rectangle around it click the left mouse button (with Shift key still depressed). Active area points should be added at all points along the traced polyline (between your specified start and end points).
- To add further, non-traced points to your active area continue to left-click on the map, but without depressing the Shift key.
- Double-click to stop adding points and to close the active area polygon.

(i) Charting of 1D model results has been enhanced to allow easy selection of multiple results for the same plot. When initialising a plot you can now select multiple 1D units either on the map or in the network table. Then, when you access the plotting function (as normal), the revised plot tool window

will list your selected units together with a full list of units in your 1D network enabling you to add or remove further units from your selection for plotting.



Once the parameter and timing are selected clicking the plot button will generate a chart showing data from all selected units together:

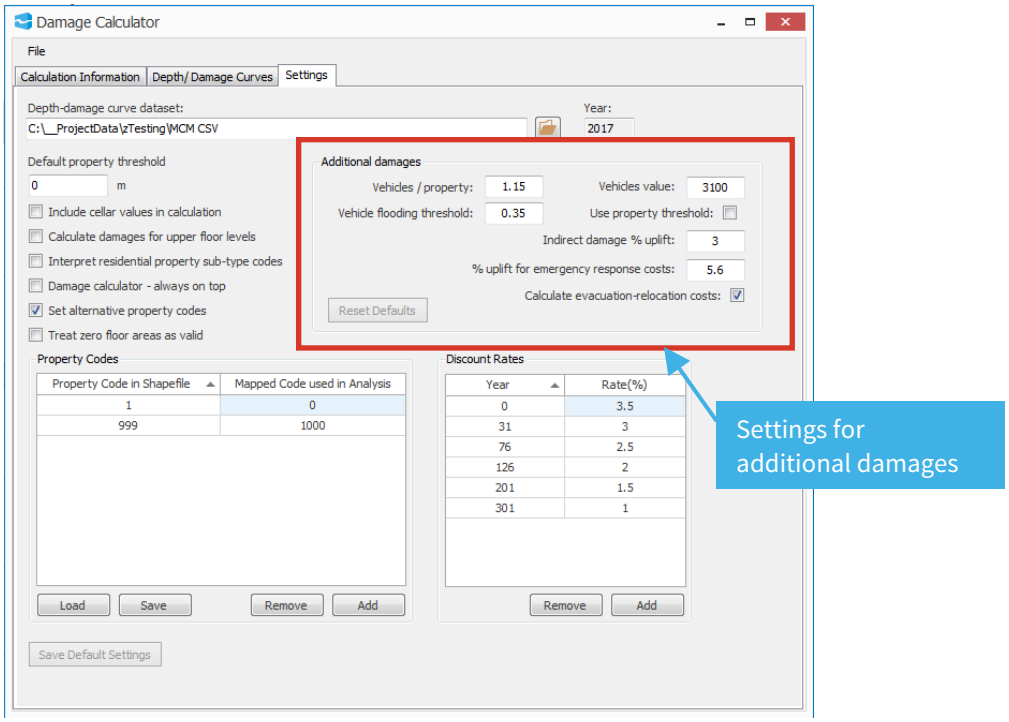


(j) The Damage Calculator tool is enhanced to include options to calculate additional damages beyond the direct property damage due to flood levels.

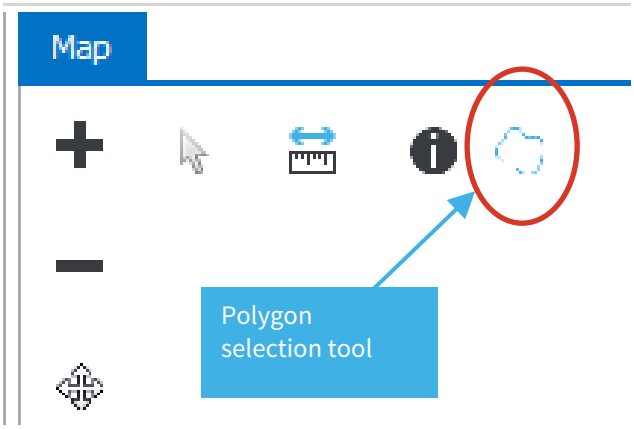
- Vehicle damages
- Indirect damages to non-residential properties
- Emergency response and recovery costs
- Evacuation and relocation costs for residential properties

Each of these four additional damages are calculated as separate damage figures against each (applicable) property and as an overall total for each dataset analysed, e.g. total vehicle damage for 100yr return period 2050 epoch event. If multiple input datasets are specified, then the additional damage totals will also have AAD and PVD values calculated. These data will also be included in the summary spreadsheet that can be exported from Damage Calculator (using the "View Summaries" button).

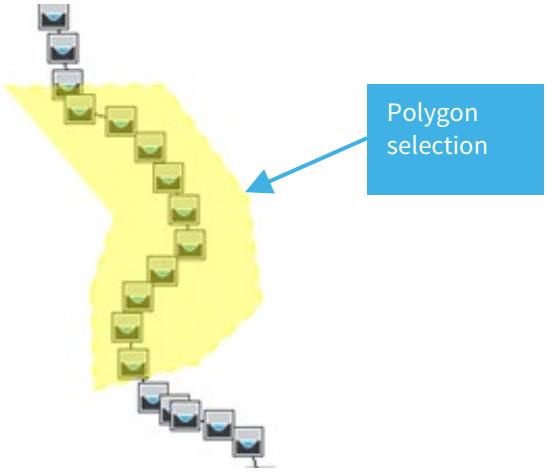
The Settings tab provides the options to affect each of the additional damage calculations:



(k) 1D node selection now includes an option to select multiple nodes by "drawing" an irregular polygon around all required nodes. Activate polygon selection by clicking the icon in the upper left corner of the map:



Left click on the map to start drawing your selection polygon. Each subsequent click will add extra points. The polygon will be displayed as a semi-transparent, yellow shape. To end drawing click with the Ctrl key depressed. The nodes within the polygon will be highlighted and the selection mode will be returned to the default mode (i.e. rectangle selection).



(l) Enhanced auto-georeferencing when loading 1D networks without an associated gxy file. Flood Modeller will now try to position all 1D units by applying the following conditions:

- River sections with non-zero coordinates will be located in their correct position on the map.
- Non-georeferenced units between these river sections will be located on the map between the river section locations. If there are multiple units between river sections, then these will be distributed linearly in the space between the river sections.
- Any units that can't be positioned using the above conditions will be located adjacent to the main network and distributed linearly within the zoom extent of the georeferenced part of the network. Previously the current map zoom extent was used to encompass these non-georeferenced units (relying on the user to set this extent prior to loading the network).

Note: It is still possible for some units in some networks to be omitted from the above tests and these units will still revert to a 0,0 coordinate location. Occurrences of this type should now be rare though.

(m) The model packaging functionality in Flood Cloud has been enhanced to enable a wider range of model configurations to be run in the cloud. This is in terms of model file locations and file types (and mainly applies to TUFLOW models).

(n) Flood Cloud test mode no longer requires a local Flood Modeller licence (or TUFLOW licence – implemented in v4.4). Note that test mode is only available in the Flood Cloud standalone interface (this is packaged with Flood Modeller but is different from the Flood Cloud interface accessed from the Flood Modeller Simulations tab).

Bug fixes to Flood Modeller main interface:

Some bugs identified since the release of v4.4.1 have been addressed in v4.5. The most significant fixes are listed as follows:

- 1D-2D link line generator tool was starting/ending links at position (on specified active area outline) closest to 1D cross section centre point instead of end point. In some cases this could lead to link lines starting/ending at location offset from where 1D cross section "touches" 2D active area (thus requiring additional manual editing of polylines).

2.2 Enhancements to the 1D and 2D calculation engines implemented in v4.5

The following sections detail changes and enhancements made to Flood Modeller 1D and 2D solvers.

2.2.1 1D Solver enhancements

(a) Links with TUFLOW HPC have been extended to enable inclusion of ESTRY components in the linked 1D to TUFLOW HPC model.

(b) New type of bridge unit added to the 1D solver. The new bridge unit aims to improve the calculation capabilities of the software concerning the flow through bridges where the dominant cause of losses is the friction from piers. It utilises the empirical equation derived by Yarnell (1934). The addition of this unit provides a new option for modelling a bridge, in particular where low flow is more frequent.

(c) New asymmetric culvert unit added which enables the definition of an irregular channel shape. It also offers a choice of roughness coefficient, i.e. Colebrook-White or Mannings.

(d) New "test Run" mode implemented/finalised - no licence check; no results output; limited simulation duration

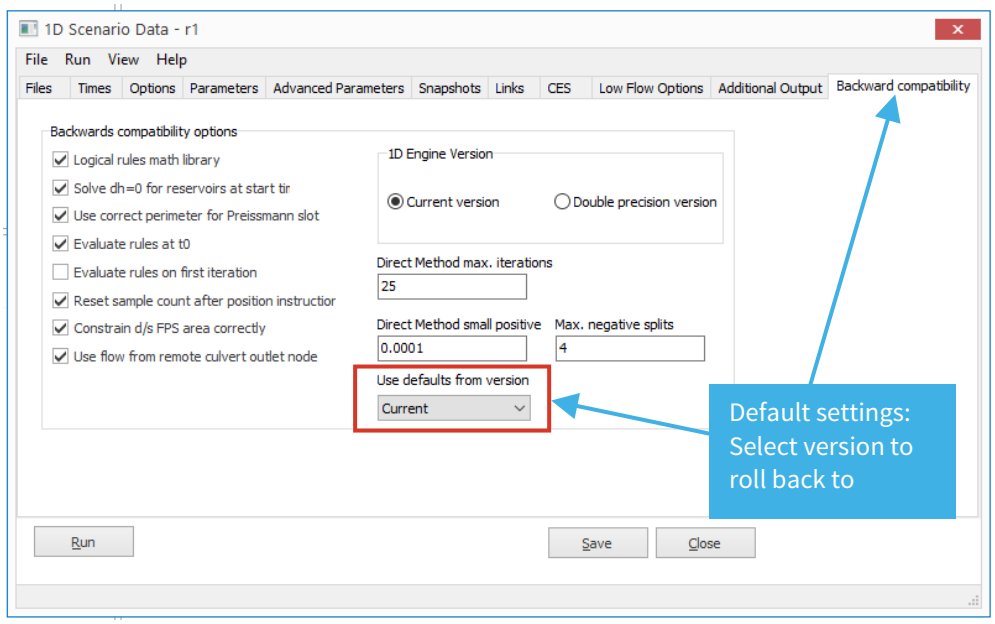
(e) Dlls are now loaded using the dll's own folder as top of the search path hierarchy for further dependent dlls – improves the ability to load TUFLOW dlls for linked simulations

(f) Added extra cumulative volume (to 2D) per node output to zzx for "2D Flow" [TUFLOW] option

(g) New default minitr = 3 (and consequently avitr=3.5)

(h) Linking to TUFLOW HPC - **new timestep synchronisation option (default=ON)** so that the timesteps of TUFLOW HPC and Flood Modeller 1D always coincide *exactly* when they exchange variables.

(i) Ability to rewind to previous version's defaults implemented (see above options). Note you can set the version to roll back default settings to in the 1D model interface (currently only roll back option is v4.4):



(j) If a non-existent Results folder is specified, this is automatically created (one level down only).

(k) Ability to write a temporary (short, fine temporal resolution) “rolling” zzn file to aid debugging close (in time) to problem area.

(l) Improved error /warning messages on:
   a. Licence, etc. failures
   b. Failure to load/find TUFLOW dll
   c. two rules simultaneously applying (better identification of rule numbers)
   d. Allocation errors, e.g. "Too much memory requested"

(m) Null stage values (e.g. returned from dry 2D areas) are not subject to (alpha-)relaxation; this prevents occasional spurious non-convergence warnings.

2.2.2 2D (HD) Solver enhancements:

(a) 2D solver can now write out the calculated maximum extent (i.e. 9999 timestep) in an ASCII grid format. User can set whether to write these data out using the 2D model interface (although the default setting is to write this grid).

(b) 2D solver enhanced to allow simulations to start without the user needing to specify a 1D-2D mass balance diagnostic filename. Previously this would cause the solver to crash unnecessarily.

(c) NetCDF and XMDF results file output formats now fully supported.

(d) Check files may now be output in GeoTiff format (improved option for rotated grids - no holes shown).

(e) New functions in SWMM link to be able to extract flooded and ponded flow from a SWMM node (via a Q-link).

(f) Stability of Q-link return flow improved.

(g) Improved synchronisation of SWMM-Flood Modeller 2D time steps/simulation times.

(h) Improved mass balance calculation on H-link lines; H-link cells accounted for separately.

(i) Improved diagnostics (messages & quantity added to MB file) if trying to extract more flux than it can from a Q-link.

(j) Superfluous/irrelevant warning about SWMM being in US units removed.

(k) FAST module – shapelib.dll file updated to use more recent (non-obsolescent) Microsoft VC++ redistributable (dependencies).

(l) Removal of extraneous/excessive "this is the first and last [negative depths] warning" messages.

Bug fixes to Flood Modeller solvers:

Some bugs identified since the release of v4.4.1 have been addressed in v4.5. The most significant fixes are listed as follows:

1D Solver:

(a) Errors in automatic top slot for curved-topped conduits (Circular, Full Arch, Sprung Arch) fixed.

(b) In ReFH boundaries with a user-defined rainfall profile, the $\alpha(T)$ parameter was previously incorrectly

calculated, if a T-year flood return period was set within the form (return periods are not used for observed rainfall); **this could have an effect on C_{ini}, the initial catchment wetness, and hence the loss model and resultant runoff**. For v4.5, the $\alpha(T)$ parameter is effectively set to 1 if an observed rainfall profile is being used (unless overridden by a user-defined value).

(c) The Direct Method now exhibits consistent behaviour when failing due to inappropriate initial conditions in the model file (.dat) and network connectivity.

(d) Direct Method failure for a QH Control with downstream water level below crest level fixed.

(e) Error if number of snapshots exceeded maximum (10) now fails gracefully with appropriate warning.

(f) Minimum p1 (and p2) for sharp-crested weir (SCWEIR) raised to 0.1m (with warning), in line with recommendations; was previously calculating unrealistically high ce coefficient values at previous minimum of 0.01m.

(g) Maximum number of boundaries in a model increased from 300 to 1000 - was causing “illegal storage” errors with models with > 300 boundaries.

2D Solver:

(a) Failure caused by very long combined polyline-point file names now fixed.

3. Flood Modeller v4.4 – changes and enhancements

3.1 Updates in Flood Modeller in v4.4.1

The full version number of Flood Modeller v4.4.1 has changed from v4.4.6754.21675 to v4.4.6803.28334. The following changes have been implemented in this patch release:

(a) 1D model interface bug fix so that it correctly interprets relative paths between specified file paths of referenced files and folders. Previously, a problem could occur when one specified file, or the Flood Modeller software, was on a different server to all other files, e.g. results folder specified on local machine (together with software) and model files (i.e. dat, ief, ied, etc.) specified on a network folder(s). Problem manifested itself with one (or more) file paths modified in the interface with a “File:\\\” prefix. If you made a change to model settings in the interface and clicked Save the incorrect file path would then be committed to the ief file.

(b) 2D model interface bug fix so that it saves the specified file path for 1D-2D mass balance files when defining a linked model. Not having this file specified would then cause the model to fail to run. The problem would mainly occur when the interface automatically set the name for the mass balance file (when you “drag” the 1D ief file into the 2D interface “Linked Models” tab). If you utilised the browse button to specify your own mass balance filename, then the interface worked correctly and saved this file reference to the 2D xml file. Now the interface will save the file reference whichever way the file is specified.

(c) 1D solver bug when network includes an ReFH2 boundary unit that is to be replaced by a different variation of the ReFH2 unit held in a referenced event file (ied file). Previously, ReFH2 units in event files could only replace boundary units that were a different type (but with the same name) in the 1D network file (dat file).

(d) 2D model solver has been enhanced to handle a 1D-2D mass balance file not being correctly specified. This is an optional file for a simulation, so a model should run whether it is specified or not.

(e) 2D solver bug has been fixed relating to the interpretation of point or polyline shapefiles within the input topography list. Previously, using a line/point topo modification could adversely affect the nett topography within your 2D domain if any height attributes within a topo shapefile were populated with the missing data flag (-9999). These data were read as valid elevations at runtime, adversely affecting the 2D domain and/or link line (the effects could be seen in the IWET check file). Missing data values are now ignored in the calculation of the nett topography of your 2D domain (underlying ground elevations or other valid topo shapefile data will be used instead).

(f) The Flood Cloud tool packaged with Flood Modeller has been enhanced to extend the range of 1D-TUFLOW and TUFLOW only model configurations that are compatible for cloud-based simulations.

(g) A bug discovered in the reservoir generator tool has been fixed. This ensures the depth contours are successfully and correctly calculated when using the “no of equal steps” option. In addition, the default fixed step size has been changed from 10m to 1m (1ft when working with US units).

(h) The EACSD validation check (performed when reading in EACSD survey data files) has been enhanced to match recent modifications to the EACSD survey format specification (as defined by the UK Environment Agency).

(i) The Flood Modeller User Guide has been updated. This was to update explanations of some of the recently modified tools and to correct some mistakes that were identified.

3.2 Changes to Flood Modeller user interface in v4.4

The following enhancements were made to the Flood Modeller interface for v4.4:

(a) Run TUFLOW models in cloud - Flood Cloud

TUFLOW standalone simulations (i.e. not linked to Flood Modeller 1D) can now be uploaded to Flood Cloud. The service is called Flood Cloud. This can provide the following advantages:

- Allows many simulations to be run concurrently without the need for additional TUFLOW or Flood Modeller licenses.
- Allows multiple (cloud) servers to be utilized to complete large batches of simulations quicker.

Flood Cloud batch simulations are set-up via the Flood Cloud interface accessed from the Simulation tab of the main toolbar in Flood Modeller.

This will display a new window in which you can specify a batch of TUFLOW standalone or 1D-TUFLOW linked models (note that each individual batch must all be the same type of model).

After starting a cloud simulation, the progress of each simulation in a batch can be monitored, with the interface displaying details of each simulation, including selected diagnostic data. As each simulation has completed, results can be set to be automatically downloaded back to the local machine (or downloading can be triggered manually later by the user).

(b) Run HEC-RAS models in Flood Cloud

HEC-RAS simulations can now be uploaded to be run in Flood Cloud. Model outputs are then downloaded back to the user’s machine automatically. If a batch of HEC-RAS models are uploaded then the Flood Cloud local interface reports progress of each simulation, together with selected runtime diagnostic information.

As each simulation has completed, results can be set to be automatically downloaded back to the local machine (or downloading can be triggered manually later by the user).

The running of HEC-RAS models in the cloud provides the same advantages as the other model types compatible with Flood Cloud, i.e. save time running multiple simulations concurrently, run more simulations to carry out more extensive investigations or save local resources by moving workload to the cloud (freeing local resources for other tasks).

(c) Run models in cloud via standalone interface (separate from Flood Modeller, but packaged with Flood Modeller installation). The standalone Flood Cloud interface works in the same way as the version built into Flood Modeller. It is compatible with the same model types, i.e. including Flood Modeller, HEC-RAS and TUFLOW models.

The only difference is there is no direct link to the Flood Modeller interface. Thus, there is no direct loading of simulations from an existing Flood Modeller project and no direct loading of results into a Flood Modeller project.

(d) Capability to link Flood Modeller 1D with TUFLOW HPC solver (running on GPU or CPU). Linking is setup using the same method as when linking 1D to TUFLOW Classic. However, note the following requirements to ensure compatibility of linking:

- Linking is only compatible with TUFLOW HPC versions from 2018-03 onwards due to changes that were required in TUFLOW.
- Linking is only compatible with TUFLOW HPC 2D only: the current implementation does not allow for the inclusion of ESTRY components within your TUFLOW model.
- Flood Modeller utilises an exit code received from the TUFLOW engine to display whether a linked simulation has completed successfully or failed. In certain circumstances, a linked model may return an exit code that confuses Flood Modeller into reporting a successful completion, when in fact the TUFLOW component has failed. It is therefore recommended to review your TUFLOW HPC diagnostic files to check this.
- The Flood Modeller install includes two TUFLOW files that are required to be in the Flood Modeller "bin" folder to enable TUFLOW HPC linking. These files are called; "kernels_nDP.ptx" and "kernels_nSP.ptx". Note that when TUFLOW issues an update in future you may need to manually update these files with those from your latest TUFLOW install.

TUFLOW HPC can use the GPU for calculations, thus providing significant increases in performances compared to TUFLOW Classic.

When running pure TUFLOW simulations using HPC TUFLOW, you may only see a subset of the runtime diagnostic variables / graphs that you would see when running TUFLOW classic. Consult the HPC specific log file for further runtime diagnostic information (.hpc.tlf).

(e) Performance of the Flood Modeller 2D solver has been enhanced by:

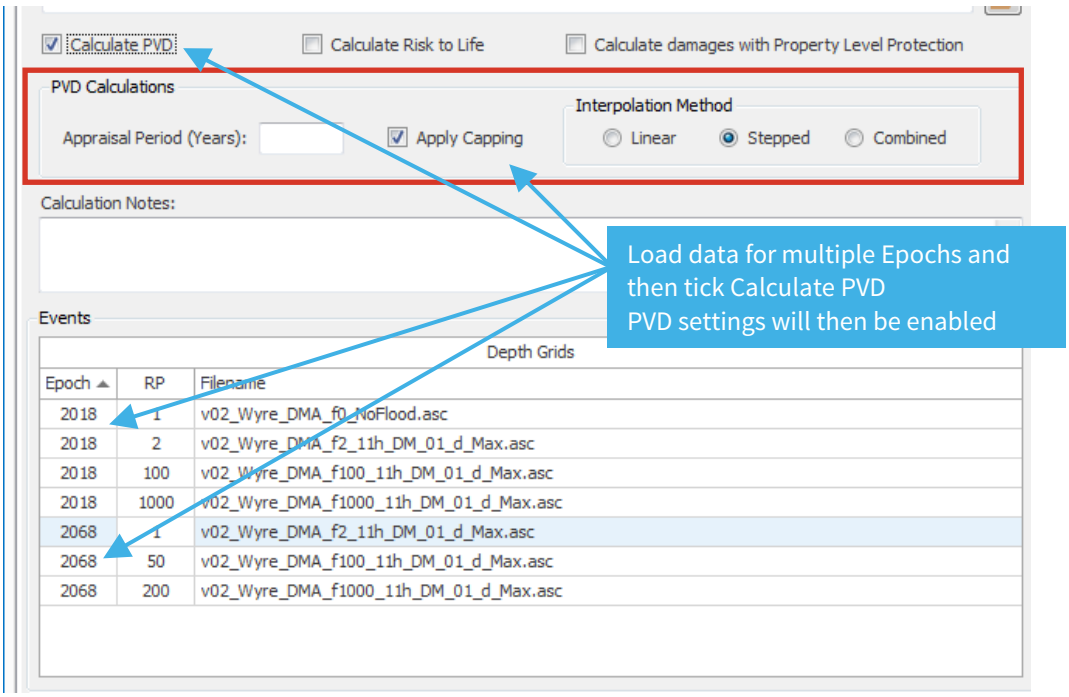
- Enabling parallelization of key calculations. This has yielded significant speed improvements compared to previous versions.
- Adding compatibility to a wider range of input grid formats. 2D models can now be defined using grid files in ASCII (.asc), binary (.flt) and geoTIFF (.tif / .tiff).

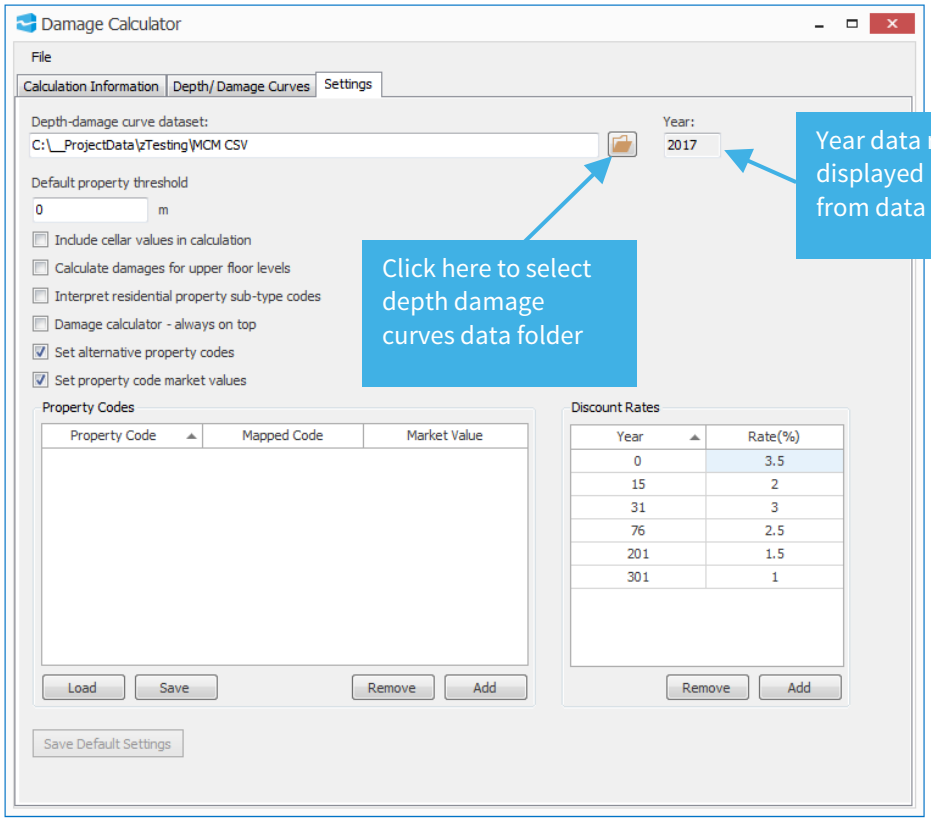
(f) Improved 1D direct steady solver: Updates to the Flood Modeller 1D steady solver to make it easier and quicker to generate initial conditions for unsteady simulations.

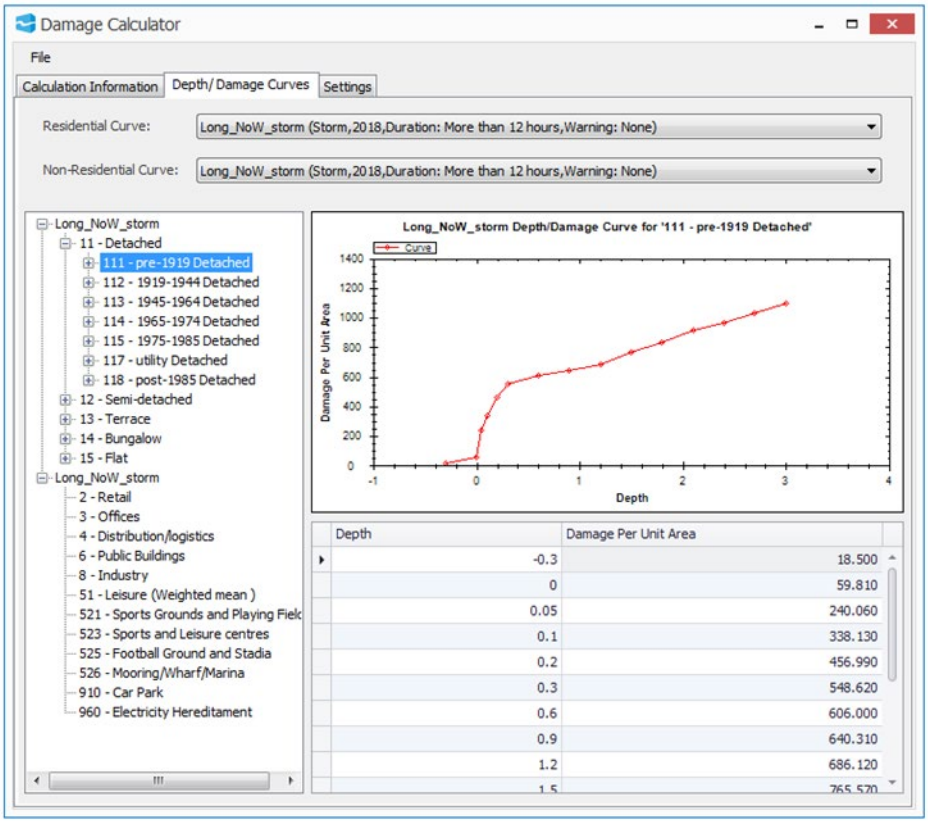
(g) Revised Damage Calculator tool – Damage Calculator has been enhanced to deliver a number of new features:

- The tool has been developed in collaboration with the Flood Hazard Research Centre (FHRC), who are part of the University of Middlesex, UK (https://www.mdx.ac.uk/our-research/centres/flood-hazard). Their research provides property depth damage data for the UK Multi-Coloured Manual (MCM). These data can be downloaded from the website; https://www.mcm-online.co.uk/ in a format that can be used directly in Damage Calculator.

- The depth damage data is combined with datasets supplied with Flood Modeller providing property type names (to appear in the damage calculator interface), default floor areas for property types and occupancy rates for property types. All these data (including those downloaded from the MCM) are in CSV text formats enabling review and further user editing in a text editor or spreadsheet.
- You can select appropriate depth damage curve sets for residential and non-residential properties individually.
- Multiple depth grids can be analysed from a single Epoch to give an average annual damage figure (AAD).
- Multiple Epochs can be specified (each containing 2 or more depth grid datasets) and the AAD values obtained can be used to calculate a present value damage figure (PVD). Options are provided to specify appraisal period, interpolation method for AAD values over the appraisal period (stepped, linear or combined linear then stepped), discount rates (against time) and capping against market values for each property.
- The results table in the interface can now be customized. You can filter data, e.g. only show properties with damages > £100,000, re-order by a column, e.g. show properties with maximum PVD or AAD, you can group data by a user selected column and you can add or remove columns from the display. The data displayed in the results table (filtered or not) can be exported as a new point shapefile containing only the visible data as attributes. This export can be repeated to produce shapefiles with different content and you can automatically add these data to your Flood Modeller project map view as it is created.

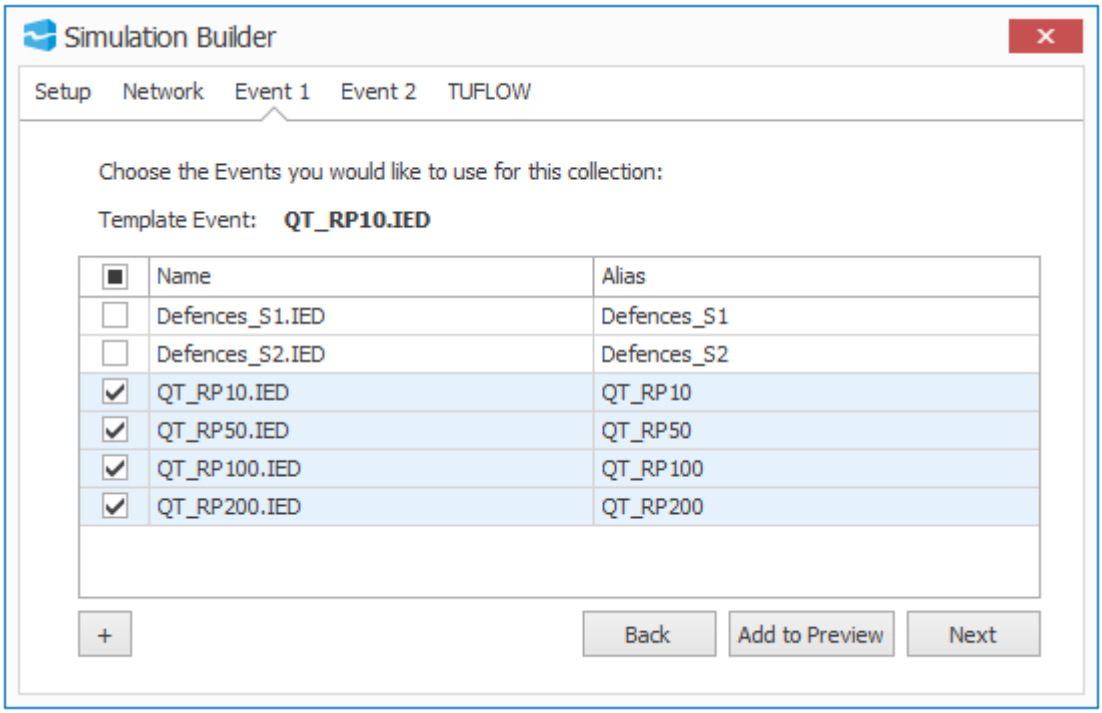


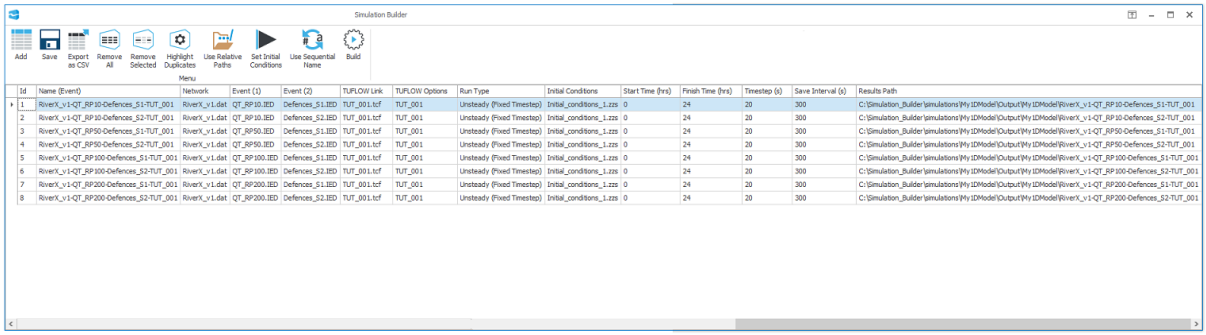




(h) Revised Simulation Builder tool for 1D models providing more flexibility when setting combinations of events and enabling users to add linked TUFLOW tcf files to their simulations. Other new features added to this tool are:

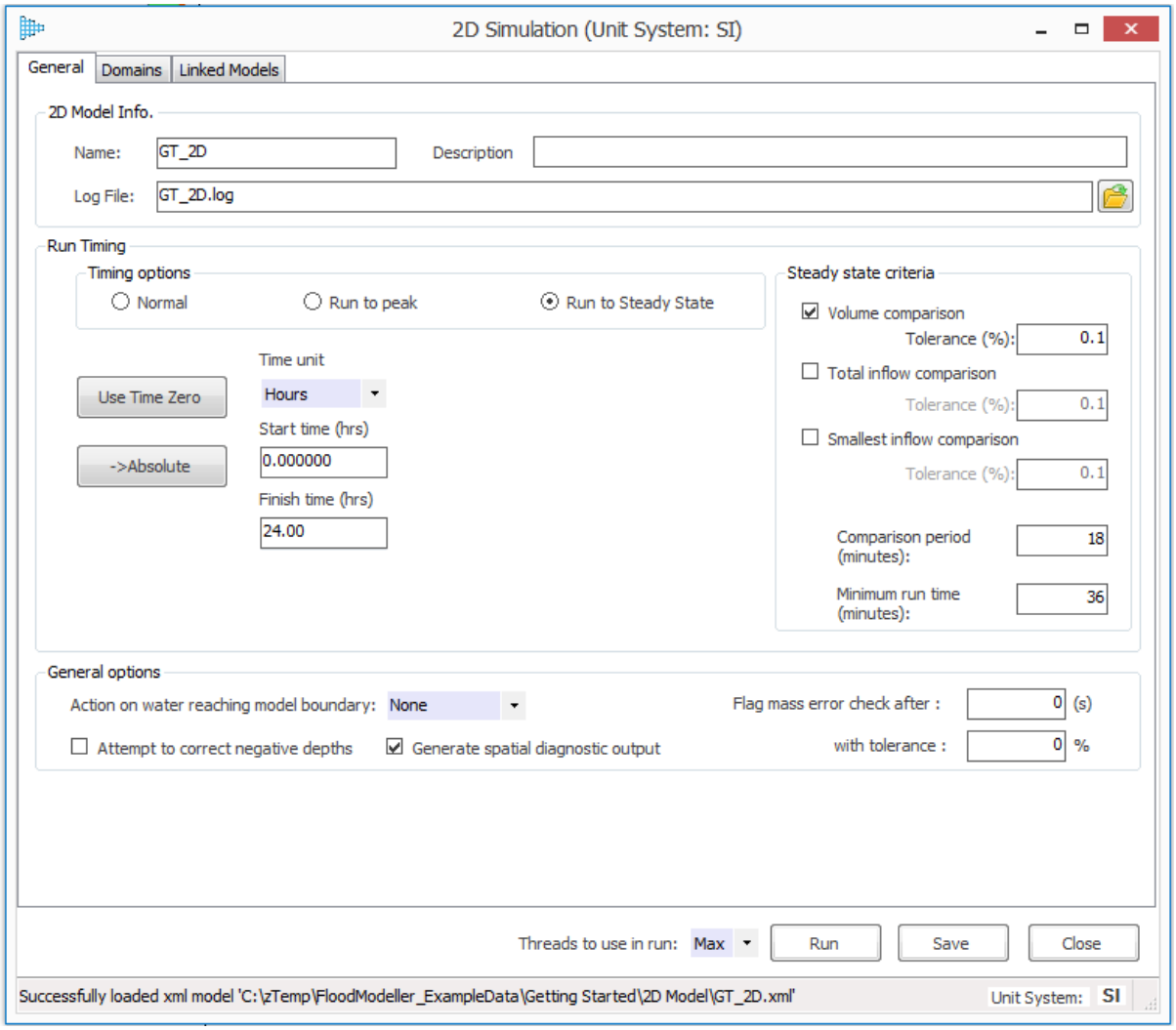
- Capability to add an alias name for each model file selected (dat or ied). This name will be used as part of the ief filename for each ief file that includes the associated file (previously the full filename of each dat or ied was used in the ief filename).
- Capability to append additional simulations to the preview list prior to building all model files. Use the Add button to go back from preview screen to model definition wizard.
- Option to browse to additional model data files (in addition to using files contained within the current Flood Modeller project).
- Option to save preview data to csv format either for creating data for audit trail or to enable you to reload data into simulation builder later to append additional model files.





(i) Revised 2D interface – provides facility to adjust additional settings. These are:

- Options for stopping simulation at user defined convergence point ("run to steady state" mode):



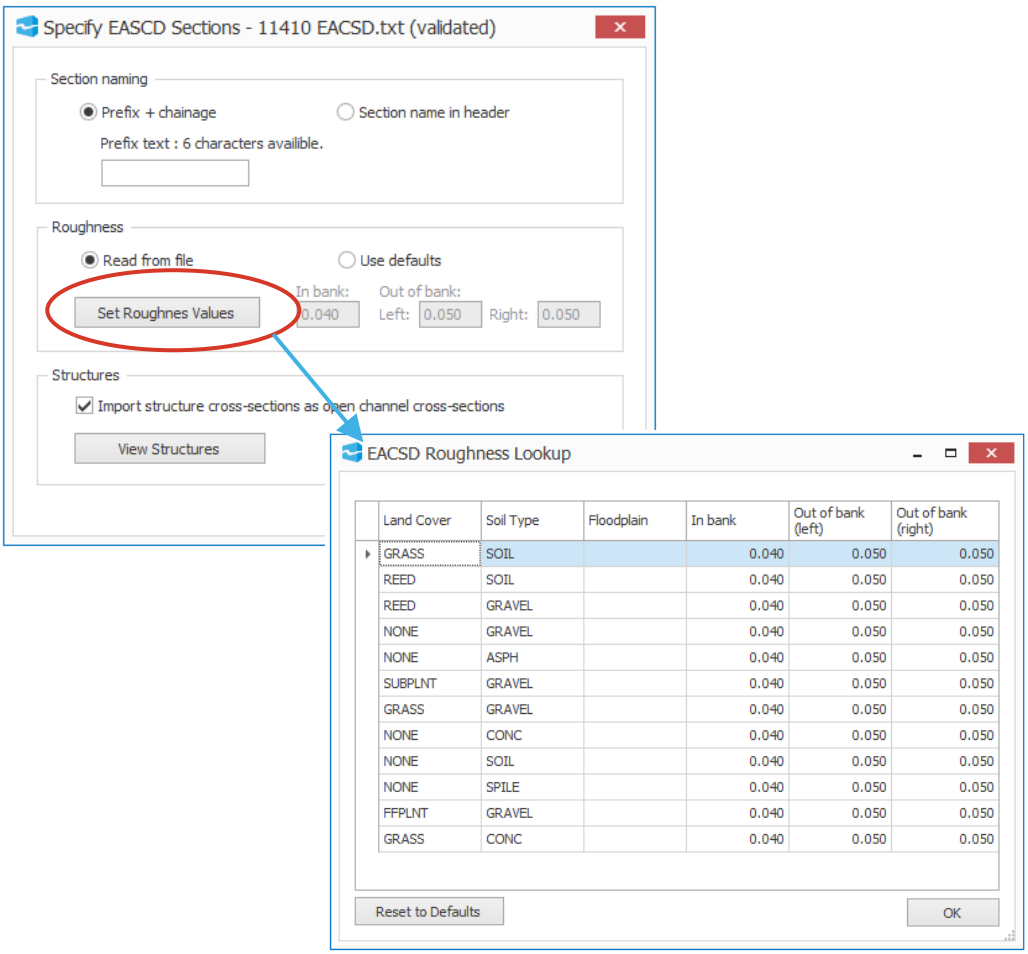
- Additional option for SWMM linking that corrects for discrepancies between specified DTM and outlet levels defined in the SWMM model. Useful for overcoming any instabilities occurring in your SWMM link.

In addition, some bugs in the 2D interface have also been addressed. These included corrections to the logic when setting simulation start and end times and corrections to the options associated with each infiltration model.

(j) EACSD import tool to import EACSD format cross-section survey data directly into a Flood Modeller network. The tool also performs a validation on your specified EACSD file (xml format) – this is the same validation process that is available from the EACSD website.

Cross sections, including those defined associated to structures, are read in. You have different options for the naming convention to use for each new section added to your 1D network and for specifying channel roughness values. The latter can be set globally or can be interpreted from specified ground/soil types in the EACSD file.

Once sections have been read in to Flood Modeller they can be “dragged” into the active network in the same way sections from other Flood Modeller networks or from HEC-RAS models are imported.



(k) Enhanced 2D FEWS adaptor: Enabling Flood Modeller 2D models to be included within the Delft-FEWS flood forecasting framework and outputs can be written out to netCDF format (as required by FEWS).

(l) Updated SWMM link: Enhancements to the way users link Flood Modeller with the US EPA Storm Water Management Model, improving the integrated modelling of sewer and drainage networks with overland flow and river systems.

The 2D model can now adjust its ground levels in the localized area around links to SWMM nodes, to smooth the transition between the two models (as SWMM in-model levels may differ from those in the 2D model DTM) and thus improve stability.

In addition, the mass balance output from the 2D model has been enhanced to provide modellers with more information for checking the validity of their model.

(m) The enhancements made to the reservoir and spill generator tools have been further refined to improve the performance of these tools and make it easier to define and calculate all required settings and data.

(n) The version of Codemeter included in the Flood Modeller v4.4 installation has been updated to v6.50.2631.502.

Bug fixes to Flood Modeller main interface:

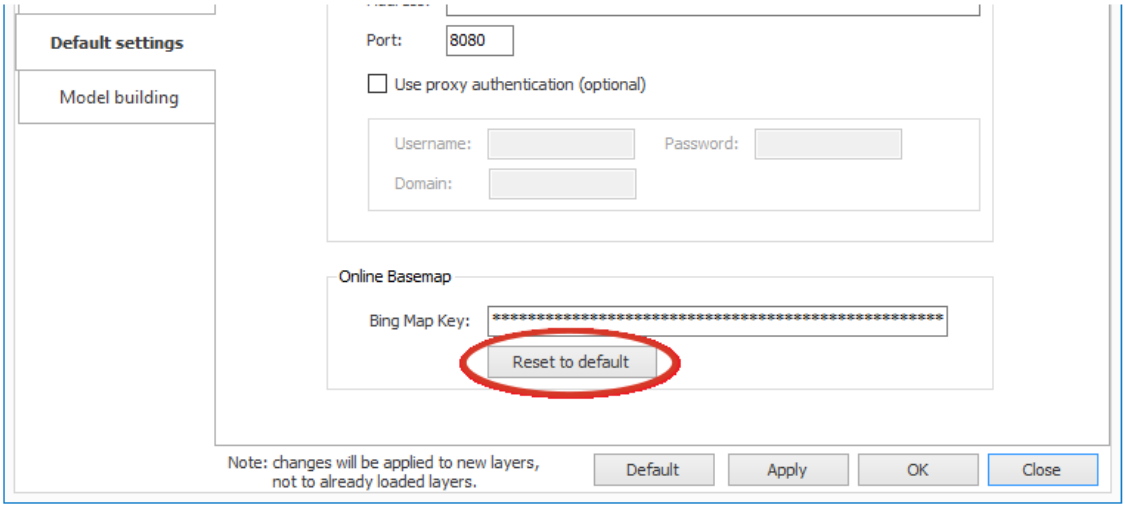
Some bugs identified since the release of v4.3 have been addressed in v4.4. The most significant fixes are listed as follows:

- Flood Modeller can now import HEC-RAS cross sections for which no distance to next values have been specified. Previously the HEC-RAS file would have to be (manually) modified prior to it being read in.

- Georeferencing models by importing visualization from different text file formats (.txt, .xy) is now working (accessed from File right-click menu item on Network table). Previously this functionality only worked when importing other gxy files.

Bing maps workaround:

An issue has been noted with the loading of base maps, in particular that the Bing maps sometimes do not load correctly. If you select a Bing base map and it does not load, open the general application settings menu (click on 'General' in the Home toolbar) and under the 'Default Settings' tab, select to 'Reset to default'. Apply these settings with the 'Apply' or 'OK' buttons. Note that you are required to close and reopen the Flood Modeller application to apply this change and access the Bing base map required.



3.3 Enhancements to the 1D and 2D calculation engines implemented in v4.4

The following sections detail changes and enhancements made to Flood Modeller 1D and 2D solvers.

3.3.1 1D Solver enhancements

(a) Link with TUFLOW HPC. See 1.1(d) for further details.

(b) Direct Method will now work with an increased number of models, in particular those with inline/offline reservoirs.

(c) Licence check removed from linked TUFLOW "Copy Only" runs.

(d) ReFH2 bug fix - whereby an infinite loop could occur when running models containing more than one ReFH2 unit.

(e) Runs are now terminated "gracefully" when closed from the main user interface.

(f) Bug fix - if Eastings/Northing not defined for an ReFH unit, this could cause errors.

(g) Reading empty General System Parameters from network (.dat) file could cause them to be interpreted as zeroes - now reset to default values in such cases.

(h) Improved log /diagnostic file output, most significantly with respect to linked TUFLOW models/files and estimated finish time.

(i) Increased maximum cross-section limit for Sediment transport simulations.

(j) Round-nosed broad-crested weir (RNWEIR) - division by zero check implemented for p2=0 (used for variable modular limit).

(k) Time scope check for rules units over simulation duration could be incorrect if time units were not seconds. Fixed.

3.3.2 2D (HD) Solver enhancements:

(a) Highly-improved speed performance, due to increased CPU parallelization, when run over multiple CPU cores, and other speed improvements. Target number of cores on which to run a simulation can be specified from a command line or by the user interface.

(b) User may specify a deactivated area.

(c) Support for increased input/output grid formats.

(d) Compatibility with GeoTiff (for topography input).

(e) Compatibility with ESRI flt grid (for topography input).

(f) XMDF (gridded time series output).

(g) NETCDF (gridded time series output).

(h) GeoTiff format used for output check files with rotated grid.

(i) Elevations can now be read from PolyLineZ shapefiles for topographic modifications.

(j) Compatibility with FEWS / Flood Modeller Adapter formats.

(k) "Stop on convergence" methodology and documentation improved.

(l) Statistics on high Cr and Fr numbers, and negative depth counts output to diagnostics log file.

(m) Table of information regarding linked nodes - elevation, link type, coordinates, node label, etc. output to log file for linked models.

(n) "W" link will apply the link cell water elevation in preference to that from an adjoining cell, where appropriate.

(o) "W" link bug fix, whereby the full breadth of a weir link line was not being applied to the weir equation, thus resulting in potential volume loss.

(p) Option to adjust the ground level for a SWMM-linked node in the case of a discrepancy between the two elevations.

(q) Bug fix on failure to detect boundary label in csv input file - now stops with appropriate error message.

(r) Bug fix - correct maximum area being picked if using multiple Green-Ampt infiltration polygons.

3.3.3 2D (FAST) Solver enhancements:

(a) Common data read now shared with [hydrodynamic] 2D engine; therefore, inputs should be identical between the two (other than method-specific parameters).

(b) Support for NETCDF gridded time series output.

(c) Compatibility with FEWS / Flood Modeller Adapter formats.

4. Important information for sentinel dongle users

Users with the old-style Sentinel standalone dongles (predominantly black or purple colour) and a valid support/maintenance contract are required to run the utility *c:\program files\flood modeller\bin\dupdate.exe* (assuming *c:\program files\flood modeller* as the installation folder) after installation in order to upgrade the dongle to be compatible with the current version of Flood Modeller.

5. Flood Modeller v4.3 – changes and enhancements

5.1 Changes to Flood Modeller user interface in v4.3

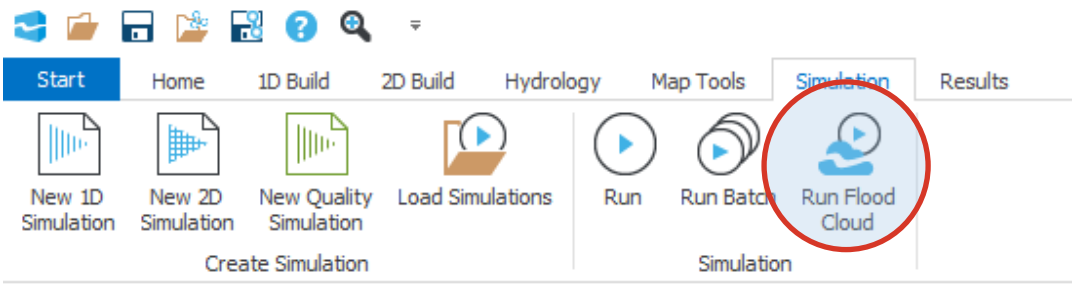
The following enhancements were made to the Flood Modeller interface for v4.3:

(a) Run models in cloud - Flood Cloud

Flood Modeller simulations can now be uploaded to an associated cloud service. The service is called Flood Cloud. This can provide the following advantages:

- Allows many simulations to be run concurrently without the need for additional Flood Modeller or TUFLOW licences.
- Allows users of the Free edition to run models that would normally require a paid-for licence
- Allows multiple (cloud) servers to be utilized to complete large batches of simulations quicker.
- Frees up local computer resources for other tasks (that in the past might have been taken up with Flood Modeller simulations).

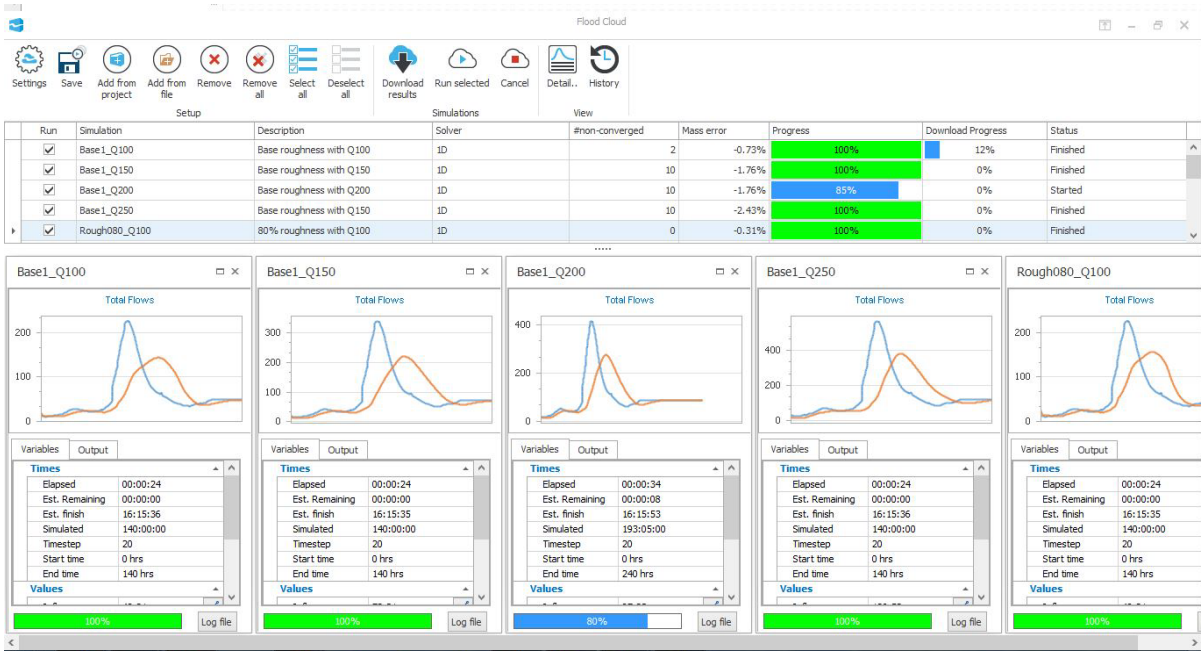
Flood Cloud simulations are set-up via a new interface accessed from the Simulation tab of the main toolbar in Flood Modeller.



This will display a new window in which you can specify a batch of 1D, 2D, 1D-2D linked or 1D-TUFLOW linked models (note that each individual batch must all be the same type of model).

The Flood Cloud interface also allows you to interact with your cloud account. Settings to change include turning on your cloud service (before a batch run), specifying the number of machines to utilize and reviewing your account details.

After starting a cloud simulation, the progress of each simulation in a batch can be monitored, with the interface displaying details of each simulation as shown below:

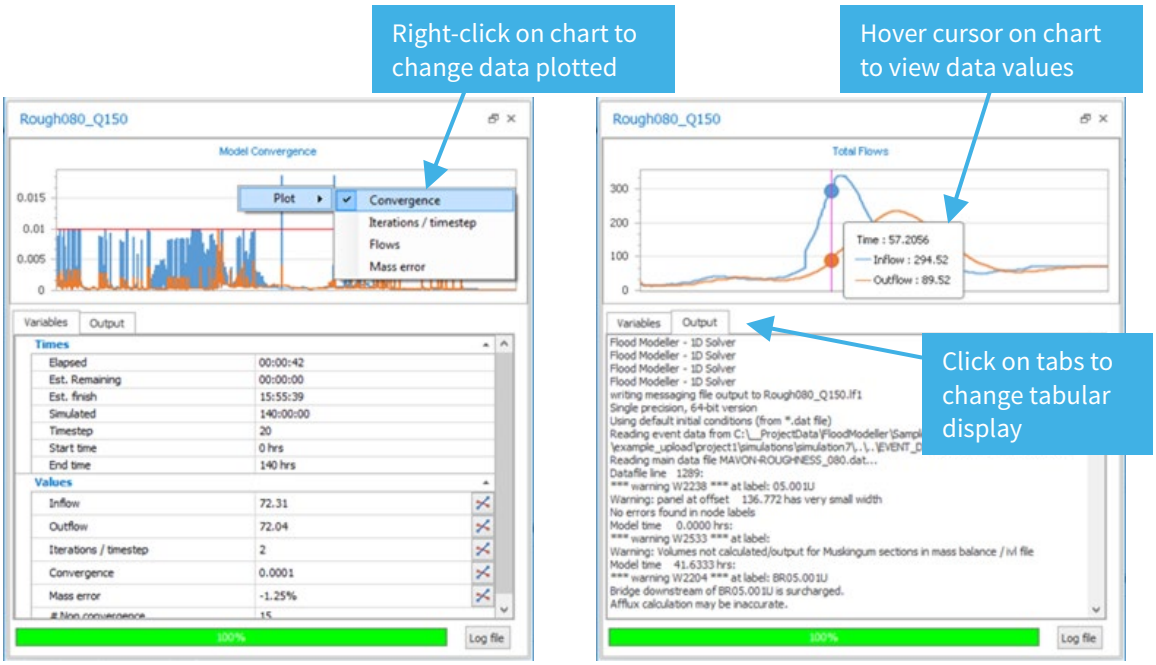


The system allows you to leave simulations running when you end your (local) Flood Modeller session and then re-access the progress and download results in a subsequent, later Flood Modeller session.

Note that credit (cloud hours) must be bought in advance of its use in the cloud. This can be done through the Flood Modeller sales team.

(b) Revised Simulation Windows for 1D models and 1D-2D linked models

The window displaying progress while a 1D simulation is running has been redesigned to deliver an enhanced display. This shows metadata for the simulation coupled with live data from the simulation in both graphical and tabular formats.

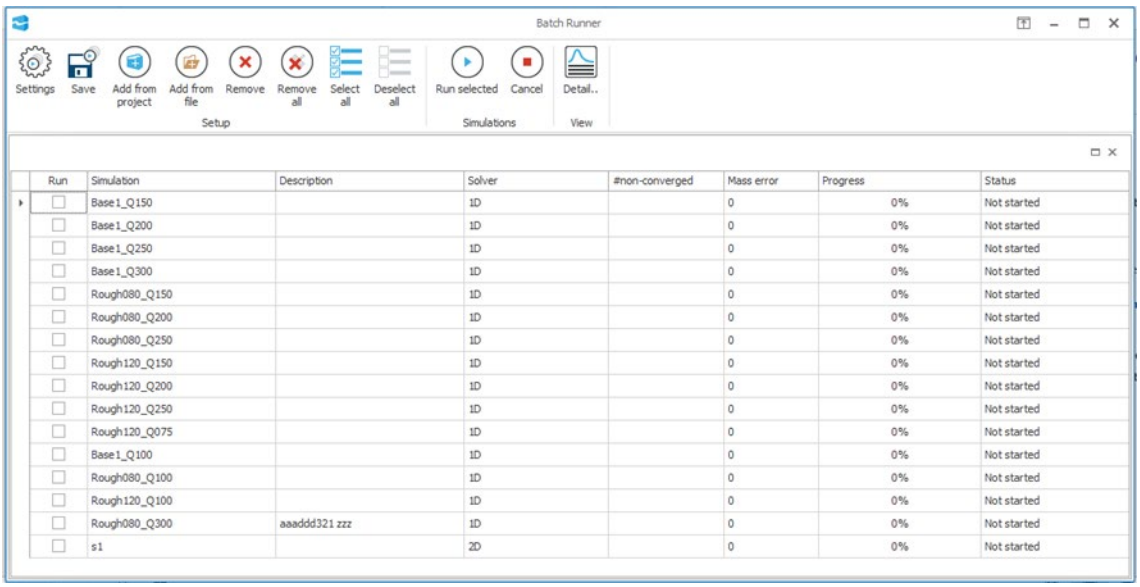


Furthermore, the style of this window has been updated to be more in keeping with the styles used by other current software.

(c) New batch runner interface that is compatible with all model types

The batch runner functionality has been enhanced in v4.3 to enable all model types to be included in a batch, i.e. 1D, 2D, 1D-2D linked and 1D-TUFLOW linked. There is a new batch runner interface to enable you to specify the simulations to be included in a new batch run. This is accessed from the main toolbar Simulations tab. The interface allows you to automatically add all simulations in the current project to a new batch (and then edit these to obtain the required list).

The interface has been designed to have similar look and feel to the Flood Cloud interface.



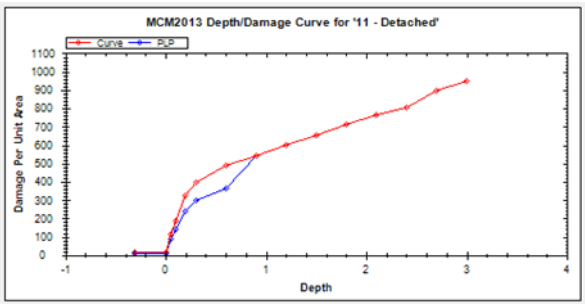
Run	Simulation	Description	Solver	#non-converged	Mass error	Progress	Status
	Base1_Q150		1D		0	0%	Not started
	Base1_Q200		1D		0	0%	Not started
	Base1_Q250		1D		0	0%	Not started
	Base1_Q300		1D		0	0%	Not started
	Rough080_Q150		1D		0	0%	Not started
	Rough080_Q200		1D		0	0%	Not started
	Rough080_Q250		1D		0	0%	Not started
	Rough120_Q150		1D		0	0%	Not started
	Rough120_Q200		1D		0	0%	Not started
	Rough120_Q250		1D		0	0%	Not started
	Rough120_Q075		1D		0	0%	Not started
	Base1_Q100		1D		0	0%	Not started
	Rough080_Q100		1D		0	0%	Not started
	Rough120_Q100		1D		0	0%	Not started
	Rough080_Q300	aaaddd321 zzz	1D		0	0%	Not started
	s1		2D		0	0%	Not started

(d) Enhanced Damage Calculator including property level protection, export results to shapefile format and use property shapefile or csv formats.

The Damage Calculator tool has been enhanced to offer wider functionality. In summary, the

additional features are:

- Compatibility with shapefile format (coupled with associated attribute file) for property data inputs (previously these data had to be converted to csv format prior to use in the tool).
- Option added to export results to a point shapefile and automatically upload to current Flood Modeller map view. These data are a copy of your input property data shapefile, with additional attribute fields added to hold the calculated damage data for each property.
- Introduction of Property Level Protection damage calculations. You can define a revised damage curve to account for a degree of property level protection (e.g. delay the start of significant damages until a depth threshold is exceeded). If selected, the adjustment is applied to all property types. The property level protection data are stored in a separate database to the main damage data and the user guide provides instructions on deriving and editing these data. The data can be reviewed in a new tab that is visible in the interface



Depth	Damage per Unit Area with PLP	Damage Per Unit Area
-0.3	9.390	12.520
0	9.390	12.520
0.05	85.290	113.720
0.1	138.728	184.970
0.2	240.960	321.280
0.3	299.670	399.560
0.6	365.925	487.900
0.9	538.160	538.160
1.2	597.570	597.570
1.5	649.970	649.970
1.8	711.330	711.330

when you select the option to apply property level protection. Furthermore, the impact of a chosen property level protection can be inspected on the damage curve plots, which can show with and without property level protection curves together.

- In addition, some general interface improvements have been implemented to make Damage Calculator more intuitive and easier to use.

(e) Project export function

An export function has been added to Flood Modeller to enable you to package up the current project to a single zip file. This allows projects to be easily shared between users.

The zip file includes a new Flood Modeller project file (fmpx file) generated by the export function. This references all files stored in the project using relative paths. Consequently, after unzipping an exported project, you can just load this project file in Flood Modeller to review the associated data, re-run simulations, etc.

When the export function packages up all simulations in your project, each one is checked and all referenced files, e.g. event files (ied files) and initial conditions files (iic files) for 1D models, are copied into the exported zip file. In addition, paths to these files are converted within each model file to relative paths (to their location within the zip). This ensures any model simulations will run when a project is unpacked to another system.

The export functionality provides additional options to exclude the following project data from your export file (possibly to cut down on zip file sizes):

- The content of your project's Layers panel. Note that if you choose to exclude these data from your zip, then any GIS datasets listed in the Layers panel that are required by a (2D) simulation in your project will still be included in the export file.

- Files listed in the spatial data section of Project panel, i.e. GIS datasets referenced in the project but not added to the map view.

- Files listed in the associated data section of Project panel, e.g. reports, calculation spreadsheets, etc.

- Simulation results.

(f) Enhanced calculation of mass balance data from 1D, 2D and 1D-2D simulations.

(g) Enhanced spill generator and reservoir generator tools.

The Map Tools tab of the main toolbar provides tools to interrogate a DTM for ground levels to generate new 1D spill units and 1D reservoir units. These tools provide useful functionality, but the workflows within the tool could be inefficient with default settings that were rarely appropriate (and thus required additional manual editing to produce the required 1D units).

In Flood Modeller v4.3 these tools have been revised to enhance their usability.

The enhancements made to the reservoir unit generator tool are:

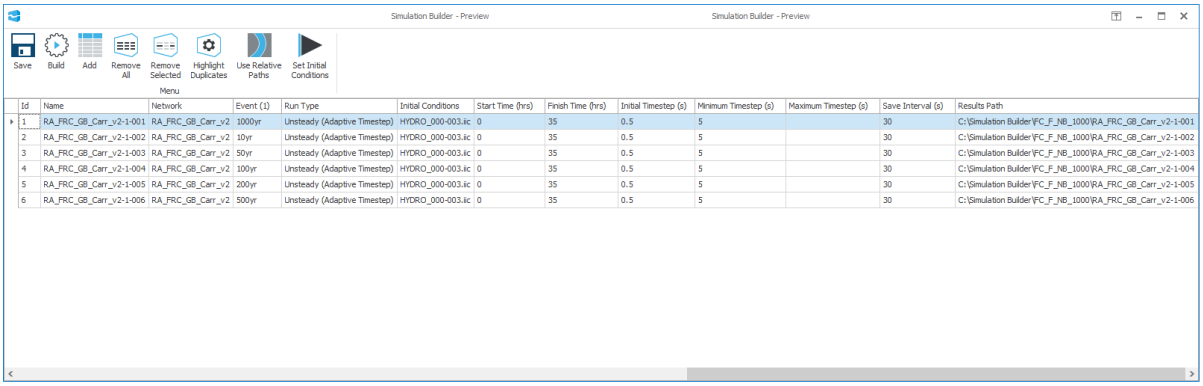
- Calculation of surface areas at each requested elevation has been made more efficient to improve performance.
- The 'auto-calculate' functionality has been removed to avoid long start-up times.
- The option to set lateral inflow labels has been removed (as lateral labels will be set later in the model build process and so is redundant here).
- The default number of contours used in calculations has increased to 25.
- The calculated area and volume data are now shown in a table on the main form, so the user can see all data together (consequently the 'View' button has now been removed).
- A 'Calculate' button has been added so you can control when the interrogation of the specified DTM can begin (i.e. when all settings are specified).

The enhancements made to the spill unit generator tool are:

- The automatic addition of "default" spill node labels and attached reservoir node labels has been removed and these spaces are now left blank for the user to fill in appropriate labels for their model.
- The default weir coefficient and weir modular limit values have been changed to match the values used by other 1D units.
- A function has been added to enable you to change multiple weir coefficient and modular limit factors in one go.
- A function has been added to auto populate weir and reservoir node names to follow a pattern, e.g. a user defined base name or base name from shapefile attribute plus incremented number.
- Input data textboxes now show only filenames with the associated full path of each file displayed in a "tooltip" (i.e. when you hover the mouse over the textbox). This is to make the information easier to read.
- Coordinate entries are now formatted correctly.

(h) Simulation Builder tool for 1D models

The Simulation Builder tool allows you to build up a matrix of 1D simulations, i.e. ief files. The tool utilises user specified event data to define all permutations and combinations of possible simulations within user specified parameters. Furthermore, the tool allows you to further customise the list of simulations prior to actually "building" them, enabling you to edit durations, timesteps, initial conditions, results destinations and run titles.

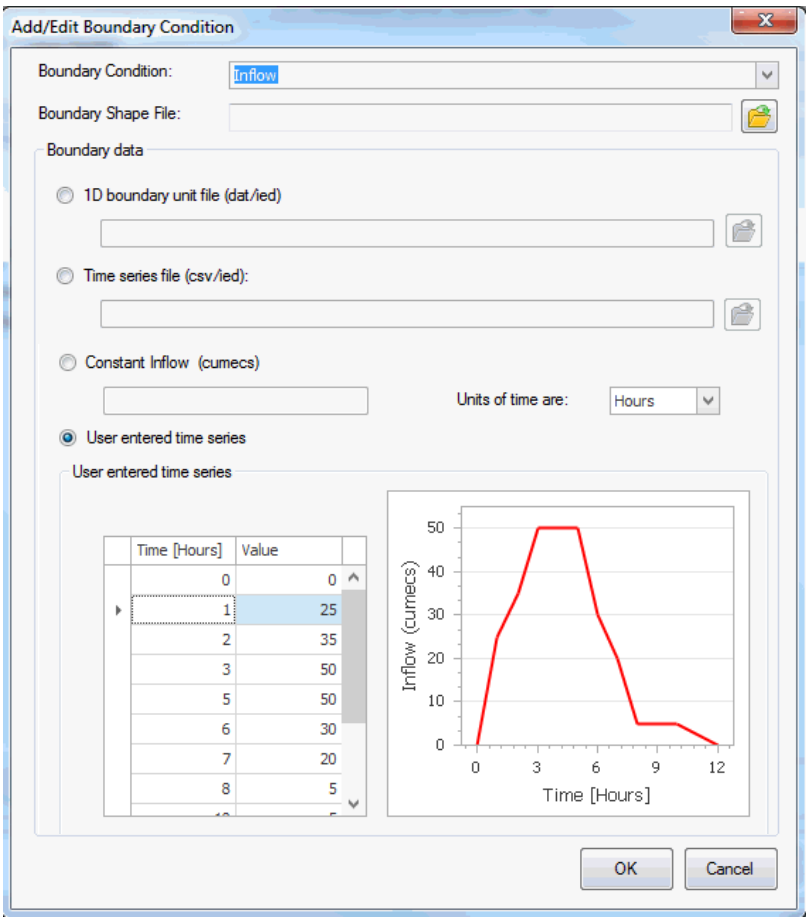


(i) Revised 2D simulation interface

The 2D simulation window has been redesigned. This is to make the process of specifying a 2D model more intuitive.

This interface consists of multiple tabs to separate the different components of a 2D model into clear categories. The structure now includes an additional tab specifically for defining linked models (1D or SWMM) and associated settings.

Other significant changes are the addition of separate pop-up windows for specifying boundary inputs, rainfall boundaries and 2D domain outputs. The relevant pop-up window must be accessed to add new, edit or review existing.



The specifying of simulation times in a 2D model has been modified to mirror the time options provided in the 1D simulation window (i.e. options to set simulation length as absolute values or

using start and end dates.

(j) New location for Flood Viewer map tiles

Bug fixes to Flood Modeller main interface:

Some bugs identified since the release of v4.2 have been addressed in v4.3. The most significant fixes are listed as follows:

- Flood Modeller can now import HEC-RAS cross sections for which no distance to next values have been specified. Previously the HEC-RAS file would have to be (manually) modified prior to it being read in.
- A user deletion of lateral inflow nodes within a 1D model now successfully also removes the associated node references from the initial conditions section of the network (dat) file.
- The option to choose whether to display or hide deactivated sections when a 1D model is "dragged" onto the map view (previously both options would led to deactivated sections being hidden on map).
- Changes to when feb file created to act as back-up – do not overwrite feb if new file is 0KB in size.
- The 2D simulation interface now correctly adjusts weir coefficients when the unit setting is changed.
- Optimal Storm Duration tool - Tabular data is not visible (although the plot is) and the file is not saving to Excel.
- Issue with REFH2 1D unit not saving user entered comments has been fixed. Furthermore, the "rainfall comment" field has been removed from this unit as it is not needed or used by REFH2.
- 1D simulation window will now prompt you if you try to run a simulation after making changes to run parameters without saving these first.
- Link to reservoir tool – this tool is accessed by right-clicking on the network table (right panel) and selecting from the Model Build sub-menu. The tool automatically creates spill units linking multiple river sections to a specified reservoir unit. The tool can now handle negative elevations within sections (and not just incorrectly set these to 0.0mAOD in the created spill units).
- The reservoir generator tool now correctly writes the eastings/northings data for each new reservoir unit correctly. Previously the tool could write these data to the wrong format in the output dat or ied file, depending on the number of decimal places specified for the coordinates.
- New location for Flood Viewer map tiles - the Flood Viewer tool includes an option to download UK map tiles from an online server, to provide background mapping for the flood extents included in the Flood Viewer project. In previous versions, the connection to this server was often unreliable, so the map tiles have been moved to a new location, which will hopefully provide faster, more reliable downloading of map tiles.

- Flood Viewer uses Adobe Flash to display the specified flood extent data. Recent changes to the Adobe default security settings no longer allow local content, i.e. content created on your machine such as a Flood Viewer project, to load automatically. To get around this issue you need to access and change the Adobe Settings as follows:

i. When you load a Flood Viewer project into your web browser you will likely see the page "hang" with only the Flood Viewer logo displayed (if an "Allow blocked content" prompt appears first then click Allow to proceed). Right-click on the centre of the page. You should see an Adobe menu. Select "Global Settings".
ii. You should see a new window pop-up after a few seconds, entitled Flash Player Settings Manager (in Chrome these menus may appear in a new tab instead). Select the "Advanced" tab (in the pop-up window) or Global Security Settings (in the separate tab).
iii. Next, in the pop-up window, click the button called "Trusted location settings" or in the separate tab, click on "Edit Locations". This will display another window that allows you to add files or folder names to a list of local places that Adobe will allow data to be loaded from. Use the Add or Browse buttons to browse to your Flood Viewer project location and add this folder to the list. Note that you can add a higher folder as Adobe should then accept anything in any sub-folders from this.
iv. After making the above changes to settings close down all the Adobe Settings windows or tabs and then refresh the Flood Viewer page in your browser. Hopefully it will then load successfully after a few seconds.

5.2 Enhancements to the 1D and 2D calculation engines implemented in v4.3

The following sections detail changes and enhancements made to Flood Modeller 1D and 2D solvers.

5.2.1 1D Solver enhancements:

(a) Added mass balance summary and % error to the summary: incorporates 2D flows (from linked Flood Modeller 2D or TUFLOW simulations); removes Muskingum reaches from calculations.
(b) On failure to load TUFLOW (including licensing issues) now causes fatal error (as opposed to running in 1D only).

(c) Models using CES (Conveyance Estimation System) Sections now available with 64-bit builds.

(d) Extra TUFLOW information added to diagnostics (*.zzd) file for linked simulations (e.g. progress, file names, etc.).

(e) Incorporated into Flood Cloud simulations.

(f) Reinstated the ability to find the isis.set file (for Sentinel dongles) into the DBD folder – facilitates different users being able to access on the same machine.

(g) Option added to turn off or rename new ".lf1" log file that provides simulation progress data to the new graphical display shown in the user interface during a simulation. This file created in the same folder location as the associated ief file. It is temporary and deleted after a simulation when run from the user interface. However, it is not deleted when simulations are run from a command line. The additional arguments derived for command line simulations enables users to either turn off the generation of the file or direct it to an alternative location (with alternative name).

Bug fixes:

- FEH boundary unit – PMF (probable Maximum Flood) could result in percentage runoff exceeding 100% - this is now reset at 100% and issues a warning.
- Length of time rule data set field increased from 80 to 255 chars – could cause read errors for large rule subsets being used.
- Bug with reservoir updating and reading *.uic files - where it would effectively switch off updating if both were present - fixed. Alleviates issues encountered when using the FEWS Adapter.
- Direct [Steady] Method - Split / join / boundary inconsistencies were leading to fatal array bounds crashes. Trapped to give more informative message.
- When a linked Flood Modeller 1D-2D simulation failed due to a 1D file access error (e.g. *.zzd file not opened), the error message is passed back to 2D, giving a more informative message.
- Reverse flow in USBPR and ARCH bridges would generate no afflux – fixed.
- Updating (*.uic) files were being written/read incorrectly for double precision runs – fixed.
- Some historic / legacy restrictions on filename lengths (in linked Flood Modeller 2D runs) were causing errors – fixed.
- Steady timestepping errors if minitr set > 2, or with negative start times, fixed.
- Data read errors for large files (> 1 million lines) displayed "line no = ******". Now outputs line number correctly.
- Abstractions connected to lateral inflows were ignored. Fixed.
- Volume balance calculation errors for surcharging geometric conduits and CES sections exceeding maximum section depth fixed.

5.2.2 2D Solver enhancements:

(a) Incorporated into Flood Cloud simulations.

(b) Basic summary information now written when in “Quiet mode”.

(c) Display issues when running on Windows 10 platform resolved.

(d) Mass balance output improvements:

- Units output to [new] second row on csv file header
- Instantaneous volume error (Qe) now reported in ft3 for runs using US units
- alternative mass % error (as % of max dV) output to lf2 - consistent with 1D
- [Gross] rainfall and loss volumes added to mass balance file
- Combined mass balance now output (i.e. 1d linked and/or multiple domains)

(e) New format of start times read from control file; applies t=0 at model start time (not 0000hrs clock time, as previously).

(f) Gives five opportunities (at 5s intervals) for the user to close csv any 1D/2D mass balance output files open or locked out elsewhere (e.g. Excel) before failing.

(g) Forced reduced computational area (when fit to the Active Area extents) to be an integer number of cells offset from the original DEM (for consistent overlap with the base DEM). Also, expanded this computational area by one cell around the edge, to allow for a boundary cell coincident with the active area.

(h) Differing CN loss values may now be applied to the same rainfall profile.

(i) Rainfall now works with >1 domain.

(j) Option added to turn off or rename new ".lf2" log file that provides simulation progress data to the new graphical display shown in the user interface during a simulation. This file created in the same folder location as the associated xml file. It is temporary and deleted after a simulation when run from the user interface. However, it is not deleted when simulations are run from a command line. The additional arguments derived for command line simulations enables users to either turn off the generation of the file or direct it to an alternative location (with alternative name).

Bug fixes:

- Forced input files to be read in as read-only; otherwise, was potentially causing errors when loaded into the Flood Modeller user interface.
- Results output filenames exceeding 200 characters now written correctly.
- Mass balance for 1D inflows from Q links when 2D timestep > 1D timestep now calculated correctly.
- Courant number calculation/output wasn't always being domain-specific, meaning it was either calculating incorrectly, outputting incorrectly or causing array bound. Now fixed.
- Mass balance files now explicitly closed (before "Simulation Finished" pause); prevents failure to write on subsequent runs.
- Mastermap lookup file was tripping an error on reaching end-of-file. Fixed, and improved error traps.
- Error trap on hydrology csv time series file not found.
- Numeric field overflow errors corrected in spatial diagnostics and "IWET" check file.

5.2.3 There have been no new enhancements made to the **2D FAST Solver** in v4.3

6. Flood Modeller v4.2 – changes and enhancements

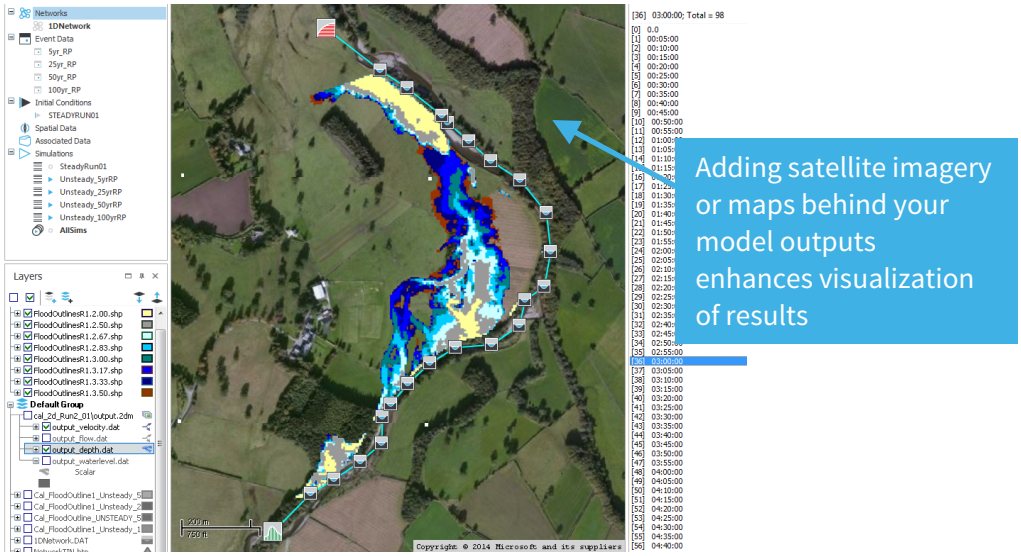
6.1 Summary of enhancements in v4.2

The following enhancements were made to the Flood Modeller interface for v4.2:

(a) An upgraded mapping component has been incorporated into the Flood Modeller interface. This provides the map view with access to the following online base maps:

- Open Street Map
- Bing Maps
- Bing Satellite
- Bing Hybrid

These can be used to provide online background mapping to models (an appropriate map projection must be specified before turning on the base mapping). Activated by selecting the required map from a dropdown list (accessed from the Home tab of the main toolbar) and then specifying the map projection for your data (selected from an inbuilt library of worldwide projections).



If you are using Flood Modeller v4.2 in a corporate environment, your internet connection (required to access online mapping) will often be via a proxy. In this case Flood Modeller v4.2 tries to auto detect the settings needed to seamlessly connect to the internet (in order to use base maps, WMS layers, etc.). However, this does mean that in some cases when you work away (and disconnected) from the office, Flood Modeller v4.2 may take a while to start up as it tries to resolve the changed environment. If there remains a problem with the base maps then you may need to remove/edit the Proxy Address in the Default Settings tab in General settings on the Home ribbon.

Bing maps are currently provided through the use of a “key” (please be aware that support for Bing maps is not guaranteed). The key is in the form of a long code string. Flood Modeller includes a built-in key, however, you also have the option to use your own key. In this case your key string is entered in the General Settings window > Default settings tab. Note the key characters are hidden so you need to copy and paste to enter your own key (a reset button is provided to return to using the key built into Flood Modeller).

Note: The revised mapping component utilised to provide base maps currently does not support the display of cell value labels for grid data layers (i.e. ASCII raster grids (.asc), binary grids (.flt), etc.). Cell values of 2D results files (2dm/dat/xmdf) can still be displayed as labels. Furthermore, both the info tool and the map status bar can display cell values for grids at the mouse cursor location.

(b) 1D event files (ied files) can now be created, edited and viewed in the same way as 1D networks, i.e. using the 1D Build tab of the main toolbar. Either an event file or a network file can be active in the interface, i.e. displayed on the map and in the Network and Nodes tables.

(c) Flood Modeller Free now includes 1D-TUFLOW linking (limited to 10 links).

(d) 1D networks now have option to add ReFH2 boundary units. The unit will link to WHS ReFH2 software to calculate hydrograph data (therefore it requires you to also have a valid licence for the ReFH2 software).

(e) Breach units now have the option of defining a “pipe” breach, i.e. a breach that starts as a small hole, grows larger and can eventually collapse to an open breach (i.e. standard breach).

(f) River cross sections can now be imported from HEC-RAS models. In addition to the cross section data the roughness values, distance to next section and georeferencing information are also imported into the 1D network.

(g) Improved handling of large 1D networks. It is now significantly faster to load and work with large networks. The synchronisation between map and tables is faster.

(h) New “method” attribute field can now be included in shape file topographic features used in Flood Modeller 2D models. This provides multiple options for applying the revised elevation value specified in the feature:

- Replace – the value specified in the shapefile replaces the elevation in the underlying raster grid. This is the default setting (and the same as previous versions of Flood Modeller)
- Add – the value specified in the shapefile is added to the elevation in the underlying raster grid

(i) TUFLOW 2D results files in xmdf format can be loaded and viewed in the Flood Modeller map. The Flood Modeller post processing tools can also be used with these data, e.g. 2D Flood Map Calculator, plot section, plot time series, etc. Note TUFLOW models generate a metadata file with extension “.xmdf.sup” and it is this file that is loaded (which Flood Modeller then utilises to read the referenced xmdf format data file).

(j) Capability to build and run 1D and 2D models dynamically linked to SWMM network models has been enhanced. Flood Modeller can now pass flows or levels to SWMM and vice versa.

(k) When dragging 1D section data onto the map there is now an option to only display the active parts of each cross section. These curtailed sections can then be used when building linked 2D models as they signify the edge of the 1D modelled area. Thus 2D active areas can be snapped to the edges of the active portions of each 1D section and 1D-2D link lines can be generated between these active sections.

(l) The 2D simulation interface has been improved to make the required settings for FAST Dynamic clearer, i.e. parameters are disabled if not required.

(m) Spill units are now represented by a new icon design on the map view. This is to provide a clearer representation of a 1D network on the map for models that include a high proportion of spill units.

(n) Updated version of the TIN Creator tool included, which incorporates some bug fixes and some rarely used functions removed (to simplify the interface).

(o) US units setting now updates all labels and tooltips with the appropriate units. Also dimensioned coefficients (i.e. incorporating gravity constant, g) change depending on units setting.

(p) Some minor bugs identified in the previous version of Flood Modeller have been addressed in this release.

6.2 Enhancements to the 1D and 2D calculation engines implemented in v4.2

The following sections detail changes and enhancements made to Flood Modeller 1D and 2D solvers.

6.2.1 1D Solver (bold text identifies those changes that are more likely to influence results)

(a) Automatically links to ReFH2 software if model specified with ReFH2 boundary units.

(b) Extension of the existing breach functionality to specify the evolution of a (circular or square) piping hole and subsequent collapse to occur within a spill unit.

(c) Orifice unit can now be circular shaped, as an alternative to rectangular.

(d) Dynamic temporary change of current working folder to that of TUFLOW for linked models – will assist with finding/loading the TUFLOW link more reliably.

(e) More input parameters read in American units, including **spill discharge coefficients and using correct parameters when units setting=US**.

(f) Up to ten free links are now allowed with TUFLOW when running in FREE mode.

(g) Improved diagnostic messaging:

- "Echo diagnostic output to run log" option initialised to "off", in order to prevent fatal errors when running simulations remotely via a dumb terminal
- "Glass wall [dflood]" exceeded warning/error now output to spatial diagnostics (*.exy file)
- Varying-shaped conduits in steady Direct Method: Warning changed to "change ignored" from opposed to "not allowed"
- Reinstatement of Steady run completion status message to screen log
- On attempting to run multiple FREE instances simultaneously (not allowed) – failure message is now brought more prominently into view
- Automatic shutdown no longer overrides "Save convergence bitmap" = OFF option

(h) Bug fix: channels specified in ied files was incorrectly causing a fatal error.

(i) Bug fix: backwards-compatibility options (Use True Slot Perimeter & Logical Rules Math Library) now default to ON.

(j) Suspended sediment now permitted to settle in reservoir units (WQ).

6.2.2 2D Solver (bold text identifies those changes that are more likely to influence results)

(a) Rainfall/hydrology improvements:

- Rainfall depths allowed (now default) as input, in addition to rates.
- **Rainfall is not interpolated between input values**
- Option to allow gross or net rainfall from hydrological boundary input
- ReFH works universally in 64-bit mode (forces ""Published Report"" option)"

(b) **SWMM link methodology improved for SWMM Outfall nodes (Q-link).**

(c) **SWMM linking methodology improved for weir links to all SWMM nodes.**

(d) **Weir linking improved for weir links with few (<3) cells.**

(e) UNC (i.e. *servername*, etc.) paths supported for input/output files.

(f) Summary info output to end of log file: final/max wet cell count, volume, extent, etc.

(g) Cell status values (in "iwet" check file) now differentiated for link and model boundaries.

(h) More input parameters read in American units, including **weir link discharge coefficients and Advanced Parameters when units setting=US.**

(i) Improved diagnostic messaging:

- Explicit error message if boundary node is not found in an ied file
- Informational "Write check files" selected status is output to log file

(j) Removed incorrect error message: "points not snapped to polyline" when snapping was evident (using polyline/point topographic modifications).

(k) Issues running 64-bit version under Windows 10 fixed (NB: The progress display text is still absent under Windows 8/10).

Bug fixes:

- **Roughness asci file & null values not scaled by length conversion factor when using US units**
- **Error in converting topographic modifications in US units fixed**
- **Error in applying null values for HEIGHT2, etc. attribute in topographic modifications**
- "2DCumulativeInflow" column in mass balance file corrected - was previously incorrect by a factor of dt (timestep)
- **Was applying twice the amount of flow for vertical flow / Q-link / W-link boundaries in multiple domain models**
- **Would not allocate correct roughnesses when applying Mastermap in a multiple domain model**
- Error trap involving long file names was causing output overflow errors
- Error on reading ".ied" files for 2nd *et seq*. boundary conditions fixed.
- Error in applying initial condition water level < 0 fixed.

6.2.3 2D FAST Solver (bold text identifies those changes that are more likely to influence results)

(a) Time series specified in csv files now supported for rainfall and boundary input.

(b) Hydrological boundaries (via ied files) now supported as input for rainfall and flow (volume) boundary input.

(c) Topographic modifications made more consistent with ADI/TVD solvers:

- **Modifications may be specified using HEIGHT[1, 2] or ELEVATION[1, 2] attributes in link lines**
- **ELEVATION[1, 2], HEIGHT[1, 2] and METHOD attributes in topographic modification shape files are now recognised**

(d) Weir boundary condition:

- **now takes into account "inland" water level, thus potentially reducing the effective head (and therefore inflow) at the boundary**
- **allows outflow if the inland water level exceeds the boundary level**
- is now specified as ""Weir"" (as opposed to "Water Elevation")".

(e) Output of interim results files, e.g. in the case of 1D-linked models, or time-sliced boundaries, now uses the output frequency specified in the Output tab, **and the model timestep determines the duration of each interim FAST simulation.** The "Write check files" option is solely used to determine the output of check files and consequently no longer used to determine model results output.

(f) More information and diagnostic messages are output to log file

(g) **Bug fix in reading HTBDY and QTBDY boundary units - in the case of reading two "merged" fields and also reading the time units properly**

(h) "Run completed" text on completion is no longer displayed when the simulation terminates prematurely.

7. Flood Modeller v4.1 – changes and enhancements

7.1 Summary of Enhancements in v4.1.1

The following enhancements were made to the Flood Modeller interface for v4.1.1. Note that all Flood Modeller calculation engines are unchanged for this release (from v4.1):

(a) The Network Comparison Tool has now been fully implemented within Flood Modeller enabling the currently active network in your project to be compared to any other user specified 1D network. The issue that made the network table display turn blank after using this tool has now been fixed.

(b) The Optimal Storm Duration (OSD) Tool has been enhanced to make it fully operational within Flood Modeller. Furthermore, it has been enhanced to run more efficiently by:

- Not displaying individual run windows on screen during optimisation
- Enabling drag/drop of simulation file from Project panel into OSD interface
- Adding ability to choose not to produce model convergence bitmaps for every simulation in an optimisation procedure (this is now the default setting).

(c) The action of switching between multiple networks contained within the same project has been made more robust so that synchronisation between map and tabular displays of the network is maintained.

(d) The capability to run hydrograph calculations for all hydrological unit types when they are part of an event file (ied file) has been implemented. Previously these “in unit window” calculations only worked when the unit was part of a 1D network (dat file).

(e) Issue with Save As function for 1D networks has been addressed. Previously the save as action would update the original georeference data file (gxy file) as well as creating a new gxy file with the new network name. Now the original gxy file is left unchanged when you Save As to create a new 1D network.

(f) In the right-click menu of the 1D network panel the option to change which data columns are displayed in the network table has been made more prominent. Previously it was accessed by selecting Edit > Change display columns, now it is accessed by selecting Select Columns. Also you can now remove columns as well as add them and your changes will be saved in the interface for future sessions.

(g) The Add New buttons for 1D and 2D simulations (in the Simulations tab of the main toolbar) have been improved to ensure they always work and correctly add your new simulation to your project and display in the Project panel. Note that new simulations can also be added by right-clicking on the Simulations folder of the Project panel.

(h) You can now define a new 1D simulation file (ief file) in an empty project, i.e. does not contain a 1D network (dat file). This is useful if you want to use the interface to quickly create and run a new 1D simulation for an existing network (and don’t want to visualise the network first). Previously attempting this action would lead to an error message. However, it should be noted that now, after accessing the 1D simulation window, you will need to specify a 1D network file using the associated

browse button before you can run a simulation (as with no dat file loaded Flood Modeller cannot pre-populate the 1D network field for you).

(i) For 1D simulations the “Echo diagnostics to run log” setting is now defaulted to "off" so that it does not cause problems when attempting to write outputs to a disconnected terminal (e.g. for remote simulations).

(j) For 2D simulations the error that could occur when log output information was too long (e.g. due to a long file path name) has now been addressed.

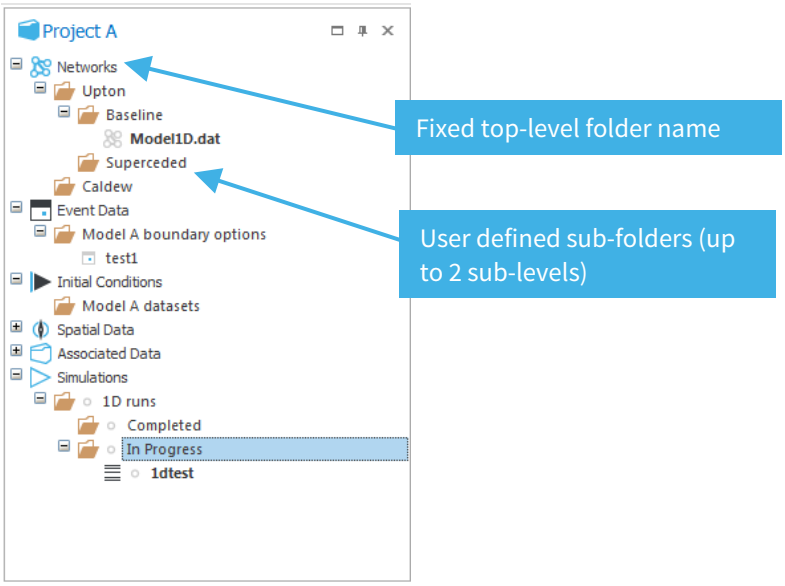
(k) Various grammatical corrections to text displayed within the interface or in outputs produced by Flood Modeller tools have been addressed.

Note that the interface executable (FloodModeller.exe) for v4.1.1 is assigned the precise version number 4.1.5816.33282 (as displayed in the upper right of the Start page > Info tab).

7.2 Enhancements to the Flood Modeller user interface in v4.1

New Features added for v4.1 (compared to previous version) were as follows:

(a) Project sub-folder functionality – Under the fixed main folder headings in a Flood Modeller project you can now define up to two levels of sub-folders to better organise the data within your project, e.g. 1D model networks could be grouped into sub-folders defined by location or defended / undefended variations and simulations could be grouped into sub-folders defined by associated network name or return period.



Note that drag and drop functionality previously available is maintained for all sub-folders.

(b) The Generic Rainfall-Runoff boundary (GERRBDY) provides a more advanced version of the SCS hydrological boundary. It incorporates a loss model (Green Ampt or SCS), transformation model and a baseflow model to compliment the user selected rainfall model. The interface to the Generic Rainfall-Runoff boundary is now fully implemented to allow this unit type to be added to new 1D or 2D models or edited in existing models.

(c) Visualise diagnostic data from 1D simulations on map – errors, warnings, etc. listed associated to particular 1D units enabling message locations to be highlighted on map. These data are provided by a 1D diagnostic text file with extension ‘.exy’. The data are also displayed in tabular form in an additional tab added to the right-hand panel. Note that existing users will need to manually add the

diagnostic tab to the right-hand panel or perform a display reset (see Layout menu on Home tab of main toolbar).

(d) Improved automatic georeferencing of non-georeferenced models – the majority of 1D model data should now be positioned within the extents of the displayed map view if no geo-reference information is available. This functionality requires background map data to be loaded first to set your map extent. Note also that some unit types will still be placed at (0,0) on the map. You may see this with some boundary units and junctions.

(e) Single setting added for setting calculation units for a project (SI or US units). Previously these were set separate for 1D and 2D models. Current setting is now displayed on user interface; in 1D network table row 1 and in header of 2D simulation interface window.

(f) New step by step guidance sections added to user guide for creating TIN files (1D flood mapping) and creating animations of modelled flooding. In addition sections defining creation of project sub-folders, defining the components of a 2D model and explaining how to access 1D diagnostic data now included.

In addition, sections have been added that define the location of commonly used ISIS functions within the new Flood Modeller user interface. This designed to aid existing ISIS users' transition into using Flood Modeller.

(g) Export option added for user to export initial conditions from a 1D network file to a separate initial conditions text file (zzs file).

(h) Capability added to select and associate a map projection to your project. Select any projection from a displayed list of known valid projections.

(i) Option to load single time step only for large 2D results files – this is to reduce memory usage when loading very large results data. This option is referred to as 'Optimise for large results file' and is provided on the time step selection window when loading a 2dm or sup 2D data file. Note with this option all time steps are still listed in the Flood Modeller interface (time step tab) but the underlying data are only loaded on request. This will lead to slower performance when animating results (recording of animations is recommended for smoother playback).

(j) Default 2D eddy viscosity setting changed from zero to 0.15 for ADI solver. This means that by default turbulent effects are considered within the 2D calculations.

(k) Default 2D velocity head threshold (for ADI solver) changed from 5 to 0.5. This lower value will improve stability for models with accelerating flows.

(l) The mouse cursor for 1D model building now changes to reflect the unit type being added. On the map the cursor icon will be distinguished by having a different coloured outline and will be partially transparent. The position where a new node will be located can correspond either to the centre or to the lower left corner of the (square) icon. Note that you can set this position, set cursor icon opacity or revert to a pencil type cursor (used for adding 1D nodes in v4.0) by changing the appropriate settings in the General Settings window.

Furthermore, the default 1D build setting has now been changed to add only one node at a time, i.e. the 'multiple add' tick box (on the 1D Build tab of the toolbar) is unticked by default.

(m) Compatibility with Windows 10 added (some minor display issues with 2D engine progress windows – these do not affect model running).

Bug fixes:

- Unit hydrograph calculation in FRQSIM unit now working.
- All 2D model file reference textboxes should now accept drag and drop from files listed in your Flood Modeller project (Project or Layers panels).

- Intelligent insert operation in Flood Modeller improved. Intelligent insert (set in 1D options) adds both a structure to a 1D network together and all associated connectivity nodes (extra river sections, junctions and optional spills) with a single click on the map.
- Trying to access the Damage Calculator tool when running in Free mode no longer causes a crash
- Minimising a FAST simulation window midway through a run no longer causes a crash
- Obsolete warning message relating to UK projections that was displayed when non-UK projections were selected now removed.
- The association of the delete key with the 1D network table is restricted to only when you are working in the Network table – to prevent accidental deleting of model nodes.
- Compatibility with 1D models containing CES sections restored (note that CES sections only work on 32-bit operating systems).
- Reduced number of prompts asking to save changes to a 1D network (dat file).
- Fixed issues with 1D network compare tool.
- Flood Modeller will now recognise availability of new results if a 1D or 2D simulation is re-run. Content displayed in UI can be refreshed to look at these new data.
- 2D simulation window now correctly saves boundary conditions using 1D event files (ied files) to the 2D simulation file (xml file).
- Copy ief function improved to work with ief files that use real dates.
- In addition, numerous minor bug fixes that relate to TIN editing, 1D and 2D model building and flood mapping have also been implemented.

7.3 Enhancements to Calculation Engines in v4.1

7.3.1 1D Solver

(a) Improved georeferenced diagnostic reporting (*.exy file).

7.3.2 2D Solver

(a) Improved discretisation of polygons and polylines, e.g. for topography modifications, boundary lines, etc., including greater consistency

(b) Improved output (more information) to run time log and output log file

(c) Negative depth, Fr and Cr warnings now written to spatial diagnostics file. Format of this file has been changed to comma separated text to improve model performance. This file can be imported into Flood Modeller map view as a point shapefile.

(d) Option to view log file (in default editor) at the conclusion of a simulation.

(e) “Add” function for topography modifications may appear in an attribute field header named ‘method’ or ‘isis2d’.

(f) PolylineZ, PolygonZ, PolylineM and PolygonM shape file types now allowed to be read in (NB Z [elevation] values are not currently read from these).

(g) Fixed issue with run failures on non-Intel processors.

7.3.3 FAST engine

(a) Fixed issue with overlaying point shape file on a polyline if their combined filename lengths exceeded 300 characters.

7.3.4 FAST dynamic engine

(a) Fixed issue with failure to read shape files for “hydrology” input.

8. Flood Modeller v4.0

8.1 Enhancements Implemented for V4.0 (from ISIS v3.7)

8.1.1 1D Solver

New Features added (compared to previous version):

(a) ReFH boundary (Urban implementation) has been revised to take into account recent published research and guidance (Kjeldsen et al., 2013), particularly with respect to the previous overestimation of the urban baseflow component.

(b) Tidal Boundaries now allow a time varying mean sea level rate-of-rise and the ability to add more than one surge, for long duration simulations.

(c) Breach formation is now allowed to be time offset, based on a trigger level being exceeded.

(d) Automatically retries to find a licence if lost mid-simulation.

(e) Double-precision (console version “Notwin”) now available.

(f) Defaults changed: maxitr=11; fatal error if event data (*.ied) file not found.

(g) Generic Rainfall-Runoff boundary (GERRBDY) now allows the standard SCS rainfall profiles to apply to durations shorter than 24 hours.

(h) Generic Rainfall-Runoff boundary (GERRBDY) now allows the areal reduction factor (ARF) to apply to all rainfall profiles.

(i) ReFH boundary summary output (*.zzh file) now displays baseflow and total flow volume outputs for the urban/rural sub-catchments.

(j) Run-time output window changes:

(k) The Run Log area is hidden by default – can be viewed by selecting the View > Run Log menu option.

(l) Estimated model completion time is displayed in the graphic.

(m) Default file viewer changed to Notepad.

(n) CES Sections now work with the TUFLOW Link.

(o) Improved/alternative method of specifying path for TUFLOW Link folder

(p) Ability to target preferred licence

Bug fixes:

- Urban ReFH user-specified initial baseflow (BF0) now applied proportionally across sub-catchments.
- Urban ReFH calibration factors now applied correctly to total output hydrograph.
- Labyrinth Weir now does not require constituent crest dimensions to be set if effective length is supplied.
- Access violation, caused by TUFLOW link error trap in initialisation phase, fixed.
- Gauge/updating unit issues – problems if data supplied before time zero; reservoir interpolation – fixed.

8.1.2 2D Solver

New Features added (compared to previous version):

(a) Improved computational speed, employing techniques such as more efficient file writing, removing redundant computational terms when zero, reducing the computation grid to the extents of the active area.

(b) Green-Ampt infiltration method introduced to allow spatially and dynamically-varying loss, based on overland flow depths and differing soil types.

(c) Rainfall input and SCS curve number loss methodology can now be spatially-varying, with differing rainfall areas and loss parameters allowed to be specified for different regions.

(d) Normal depth boundary with an undefined location can now be specified – allows water to escape out of the domain where the flow path is unknown a priori.

(e) Reading rainfall input from csv files now improved and extended: allows more than one csv file to be read; in the case of only one input series, a node label is not required.

(f) Improved run-time output console window display.

(g) Flow lines now calculate an average flow over all time steps within the output interval, rather than a snapshot of the flow at that time.

(h) Polygons (e.g. for boundary inputs) which lie partially outside the active domain area are now allowed; only the intersection is considered.

(i) Volume % error calculation more appropriate – now as a proportion of the total volume.

(j) Spatial diagnostics output improved – reports I/O errors and ignores empty files.

(k) 1D weir link now improved for case of direction from 2D to 1D

(l) Default velocity head threshold (for removal of advection term) increased to 5m

(m) 1D event data (*.ied) file Flow Time (QTBDY) and Head-time (HTBDY) boundaries may now be specified in US units when the 2D simulation is set to use US units.

Bug fixes:

- Errors if 1D link nodes not found now trapped
- Fixed inconsistencies between differing 1D and 2D start/end times (now always defaults to the earlier start and later end of the two)

- Maximum value outputs (to .dat files) now converted to US units correctly for simulations using US units
- Horizontal flow (total flow and flow/unit width) boundaries now allowed

8.2 Transition Tips for ISIS Users

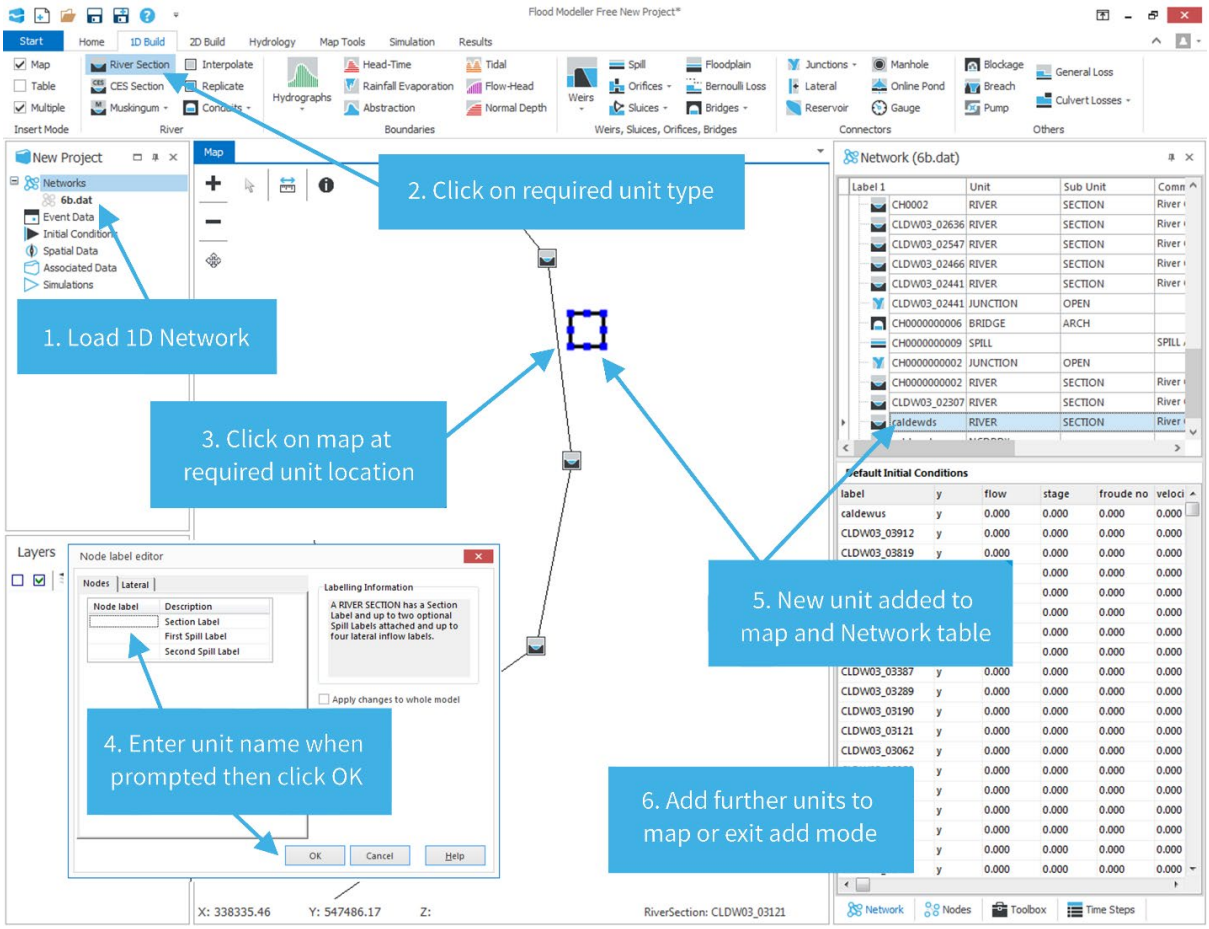
The following section explains how some key functions have changed in Flood Modeller (compared to ISIS v3.7).

8.2.1 1D Model Building

A fundamental change between Flood Modeller and ISIS is the way 1D networks are now built. The emphasis is now on constructing models on a map view with an option to display GIS layers in the background to help guide the locating of model units. The process of building new models or adding new units to existing models is as follows:

(a) For new models; first click the New button in the Networks section of the Home tab (main toolbar) and provide a name for the new model. To work on existing models, click the Load 1D Network button.

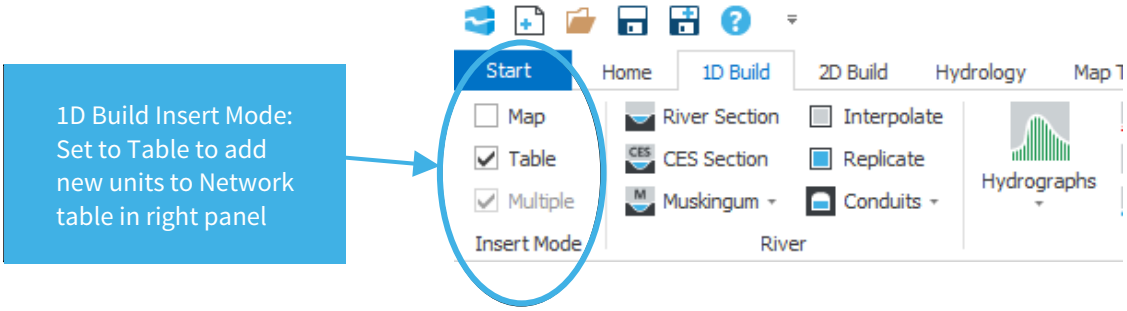
(b) Go to the 1D Build tab of the main toolbar and click on the unit type to be added. Then click on the map at the location where the node is to be added. You will be prompted to provide a unit name and the associated icon will then be added to the map (and to the Network table).



The position of the new unit in the Network table will always be after the currently highlighted unit here (or at the bottom of the table if no rows are highlighted). This is important as it may define

how the new unit is linked into the network. Therefore, it is recommended to highlight where a node is to be positioned prior to adding.

Note you cannot add a node this way by clicking on the Network table. However, on the 1D Build tab there is an Insert mode section which includes an option called “Table”, as shown below:



The default setting here is Map, i.e. to add new units by clicking on the map view. When Table is selected then a new unit will be added to the Network table (and map) as soon as you click on the unit type button in the toolbar. This is similar to the model build method of ISIS v3.7. A new unit added in this way will be automatically drawn in the map view, slightly offset from the adjacent unit (but sometimes new units may be initially positioned at the origin (0, 0) and will need to be moved manually to the required location).

8.2.2 1D Model Link Lines

When you add a new unit to your 1D network, Flood Modeller will try to automatically draw link lines on the map to any connecting units. In some cases this might not be possible and the following options are provided to update the Network links:

(a) Map refresh function: Right click on the map view and select Refresh from the displayed menu. Links and map labels should be updated to reflect the current Network configuration.

(b) If the new unit is added in the wrong position in the Network table then the expected link line may not be drawn (and unexpected lines might appear). In this case you can highlight the unit in the Network table and drag it to the correct location. Then use the map refresh function to update links in map view.

(c) If the map refresh function fails to update all links then you can try saving the current network. This also has an extensive refresh functionality built-in.

(d) If links are still not all displayed it may be necessary to re-load the network. This can be done by double-clicking on the network name in the Project panel (to the left of the map view). Note this refresh may take time if the model is large (>1000 nodes).

8.2.3 Importing existing non-georeferenced models

You can import existing ISIS 1D models into Flood Modeller even if they have no georeferencing information. In this case they will be shown more as a schematic view. Flood Modeller also includes tools to add georeferencing to networks.

In some cases when an existing model is loaded in Flood Modeller selected units may be positioned at the origin of the map, which may then be offset from the rest of the network. To try to avoid this happening, you can load background GIS data at your model location into the map view prior to loading your model. Flood Modeller will then try to use these data as a constraint to the locating of any non-georeferenced units present in your network.

8.2.4 Moving Nodes

Flood Modeller has adopted a slightly different method for moving the location of 1D node icons on the map view compared to the GIS Visualiser tool in ISIS v3.7. This is detailed as follows:

(a) First you need to activate the move nodes mode by right clicking on the map and selecting Move Nodes. This should change the mouse icon to the symbol we're using for moving.

(b) Next, drag a box around the node(s) you want to reposition. Nodes selected for moving will then each have a blue square around them to signify they are selected and below the map it should say how many nodes are selected (in the lower right corner of the map status bar).

(c) The next step depends on whether you want to move one node or multiple nodes.

- For moving all selected nodes, just drag the nodes to the new position.
- For moving a single node only, you need to hold down the 'ctrl' key while you are dragging.

Note that while dragging the nodes will not be visible (you just see the blue squares used to select them).

(d) When you have finished dragging the nodes will be redrawn in their new location.

(e) Turn off Move Nodes mode once you are finished (by right clicking and unselecting the Move Nodes option).

(f) Note that there is an 'undo' move function available on the map right-click menu. This will undo the last move operation only. Furthermore, all (move) changes are not committed until you save the network (Save Network button on Home tab).

Sometimes the cursor may change to show a different icon, e.g. if you select Pan when still in 'move nodes' mode. You can see whether you are still in the 'move nodes' mode by right clicking and checking that there is a blue box around the 'move nodes' menu item icon.

8.2.5 ISIS Mapper

Your existing version of ISIS Mapper may stop working after installing Flood Modeller. In order to activate ISIS MAPPER, you need to go to ISIS\bin folder (normally c:\isis\bin) and locate the file called: "regMapWinHGIS.cmd". Right click that file and select 'run as administrator'. ISIS Mapper should then start working. However, once ISIS MAPPER is activated, Flood Modeller may stop working. To Activate Flood Modeller, go to Flood Modeller\bin folder (normally C:\Program Files\Flood Modeller\bin) and locate the file called "regMapWinGIS.cmd". Right click it and select 'Run as administrator'.

8.2.6 Nodes tab

Note that the Nodes tab located in the same panel as the Network table (to the right of the map) does not provide an order for defining links. The Nodes tab is a new feature that enables the active network to be displayed by grouping units by type or by name. This is provided to aid an assessment of the overall network content or to aid finding of particular units within larger networks.

8.2.7 1D Scenario Simulation Window

In ISIS v3.7 this window had many tabs providing a wide variety of run options such as Advanced Parameters and Low Flow Options. In Flood Modeller these are all still provided but the majority are initially turned off so that only essential settings for simple models are displayed (i.e. files and times, etc.). You can reactivate all of these tabs from the View > Tabs menu of the 1D Scenario Simulation Window. Once a tab is reactivated then it will stay visible for subsequent sessions.

8.2.8 Selecting multiple 1D units

For long section plots you can select multiple nodes either in the Network table or on the map. On the Network table just click on the rows to select with the Shift or Ctrl keys depressed. On the map just hold down the left mouse button and drag a rectangle around the nodes to select. Also on the map you should be able to select multiple nodes by holding down the Ctrl key.

9. Acknowledgements

Flood Modeller uses the following third-party components, which are subject to the appropriate copyright and licensing conditions stated below:

9.1 The example depth-damage data included with the product represent residential property average and non-residential property average and are derived from the Middlesex University Flood Hazard Research Centre Multi-Coloured Manual datasets available from www.mcm-online.co.uk. The two example data sets provided are from the public section of the MCM online website and their use is subject to the advice and restrictions detailed on the MCM online website – the data are from 2015.

9.2 The example damage modification factors for property level protection included with the product are estimates of the damage reduction resulting from the installation of common packages of resistance and/or resilience measures for a typical residential property. These illustrative estimates are based on the way that resistance and resilience measures interact with a property, and the damage components likely to be reduced, based on the work of Stevens and Chatterton (Assessing the Economic Case for Property Level Measures in England. Committee on Climate Change, 2012). Their applicability to properties of different types should be considered, and appropriate factors should be derived for specific packages of measures.

9.3 Mapwindow ActiveX Control (www.mapwindow.org)

- MapWinGIS.ocx
- AxInterop.MapWinGIS.dll
- Interop.MapWinGIS.dll
- MapWinInterfaces.dll
- MapWinUtility.dll
- IndexSearching
- libecwj2
- geos_c

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9.7 FreeImage - This software uses the FreeImage open source image library (http://freeimage.sourceforge.net). FreeImage is used under the FIPL, version 3.11 (http://freeimage.sourceforge.net/freeimage-license.txt)

9.8 XPTable (http://www.codeproject.com/KB/list/XPTable.aspx)

9.9 Creativecommons Icons (http://creativecommons.org/licenses/by-nd/3.0/)

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9.12 Shapefile C Library V1.2 (http://shapelib.maptools.org/). Copyright (c) 1999, Frank Warmerdam.

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9.13 proj.4 (http://trac.osgeo.org/proj/). Copyright (c) 2000, Frank Warmerdam.

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9.15 LINQBridge - LINQBridge is distributed under an open-source license (MIT) that doesn't place any restrictions on what you can do with the source code. The (original) internal implementation was my own; however Microsoft, obviously, came up with the idea of having a set of query operators with those names and functioning in that manner. LINQBridge does not constitute an attempt to erode Microsoft's claims (if any) to this pattern.

9.16 EPA SWMM (http://www2.epa.gov/water-research/storm-water-management-model-swmm)

9.17 AutoUpdater.NET Microsoft Public License (Ms-PL).
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