xprafts

URBAN & RURAL RUNOFF

ROUTING SOFTWARE

Reference Manual

xpsoftware

Head Office

8-10 Purdue Street

Belconnen ACT 2617

Postal Address:

PO Box 3064

Belconnen ACT 2616

Phone : (02) 6253 1844

Fax (02) 6253 1847

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1 - An Overview

AN XP OVERVIEW

The practical implementation of any project involving storm and wastewater management is not a trivial task. Depending on the degree of complexity it may require an expert hydrologist knowledgeable in modelling techniques, and a hydraulic expert knowledgeable in the modelling of free surface and pressure flow networks. It may also require the expertise of an environmental engineer to assess pollutant buildup, wash-off and diffusion and a computer specialist to prepare the data files and coordinate the execution of various modules of the computer program.

It requires the coordinated efforts of all these "experts" to select the appropriate modelling options, to select appropriate values for input parameters, and to evaluate and interpret model output and to diagnose possible malfunctions of the drainage system and suggest remedies.

In actual projects, depending on the complexity of the problem, the calibration work can take several weeks or more. The XP environment is designed to minimise (but not eliminate) the need for human "experts" and to guide the Engineer or Scientist through the intricacies of a particular numerical model. Its aim is to improve productivity by increasing the efficiency of data entry; eliminating data errors through expert checking and the using decision support graphics and interpretation tools. The entire suite of tools creates a decision support system for the numerical model.

The main components of the XP model are THE GENERIC GRAPHICAL USER INTERFACE**, THE MODEL STRUCTURE**, **PHILOSOPHY,** and the **STRATEGY**

THE MODEL STRUCTURE

The XP environment maintains a loose coupling to the analytical model and graphical and textual post-processors, via text and binary data files. These data files are generated from the XP database when the "Solve" menu command is issued and from the analytical engine when the network is analysed.

When the "Solve" command is given, XP first performs the high-level database integrity checks as described in the documentation. If these checks are passed successfully and the model data files are generated, XP then performs the task of running the analytical engine to process the data files and generate output for the graphical post-processors to use.

When the analytical engine has completed its run any errors or warnings encountered in running the model are reported and the user is placed back in the editing environment. The model results for a selection of objects can then be viewed by using several graphical tools and reviewing text output files. Several utilities also exist for the export of model results and data to GIS, spreadsheets or other databases.

PHILOSOPHY

An expert system is "a knowledge-based reasoning system that captures and replicates the problem-solving ability of human experts" (Boose 1986) and typically has three basic components:

- a knowledge base,
- an inference engine, and
- a working memory.

The knowledge base is "the repository for information that is static and domain-wide" (Baffaut et al 1987). The knowledge base may contain not only static data that will not change from one problem to the next, but may also contain empirical and theoretical rules, and provide advice on models that may be employed as part of the solution.

The inference engine is "the reasoning mechanism containing all the procedures for manipulating, searching, and exercising the knowledge base" (Baffaut et al 1987).

The working memory is used to solve a specific problem using the expert system. It consists of the user interface to the expert system and the storage of specific problem information. The working memory also serves as the explanation device for the expert system indicating legal and illegal data and suggesting parameters.

A computer-based expert system has advantages over a human expert that include:

- An expert may retire and knowledge is lost.
- There may be better uses of an expert's time than answering user questions.
- Expertise may be expensive to deliver.
- An expert may not be available when needed.
- An expert is not always consistent.

In any particular application these reasons or others may be important in deciding to use an expert system.

Expert systems development has created the need for a specialist called a knowledge engineer. Knowledge engineering is "the extraction, articulation and computerisation of expert knowledge. Knowledge consists of descriptions, relationships, and procedures in the domain of interest" (Boose 1986). The knowledge engineer provides the interface between the human expert and the computer.

It is generally agreed that one of the largest, if not the largest, problem in expert systems development is knowledge acquisition and knowledge engineering.

XP diverges from the traditional expert system by allowing the continuous accumulation of localised expertise to be used within its shell with little assistance necessary from the software developer. The coupling of the Storm Water Management Model to the XP interface with all of its graphical tolls has created a Decision Support System (DSS) for storm and wastewater management.

STRATEGY

The graphical XP environment is, in essence, a shell that acts as an interpreter between the user and a model. The XP graphical interface provides the user with a very high-level interface to various numerical simulation programs oriented towards solving problems that may be represented as some form of link-node structure.

The main theme of this interface is Decision Support Graphics. At the front end of the interface the process of creating data for the model is made as visual as possible, with the aim of emulating real world problems as closely as possible. For example, most dialogs contain graphics that visually link the data being entered to the physical system being modelled.

The user is given continual guidance and assistance during data entry. For parameters that are difficult to estimate, the user may be advised of literature to aid in selecting a value, or an explanation of a parameter and some proposed values may be shown on the screen. If there are other ways to pick the value, typically, if the parameter is a function of other variables, the equation is shown to the user.

The user interface is intelligent and offers expert system capabilities based on the knowledge of the software developers and experienced users. For example, as various graphical elements are connected to form a network, XP filters the user's actions so that a network that is beyond the scope of the model is not created. The general philosophy is to trap any data problems at the highest possible level - at the point the users create the data.

At the back end of the user interface the results of model analysis and design are presented graphically to maximize comprehension, assist in the interpretation of results and support decision-making.

Graphical User Interface

The Graphical User Interface

The generic graphical user interface utilizes the current Windows, Icons, Menus and Pointing device technology as the state-of-the-art intuitive user environment.

The user interface can also be described as object-oriented. A user first selects an object or range of objects using the pointing device, and then performs an operation on the selection by giving a menu command. For example, to delete a group of objects they are first selected with the mouse and the "Delete Objects" command is selected from the Edit Menu.

The XP interface may be used to create a new infrastructure network as well as to edit an existing one. The XP user interface is object-oriented, which means the user selects the object, then selects the operation to perform on it.

The XP environment consists of:

- A window with a series of menus along the top of the screen used for controlling operation of the program.
- Several tool strips of icons for file operation, object creation/manipulation and short cuts to menu commands.

The elements of the interface and the method of manipulation of objects are described in the text below.

The Window

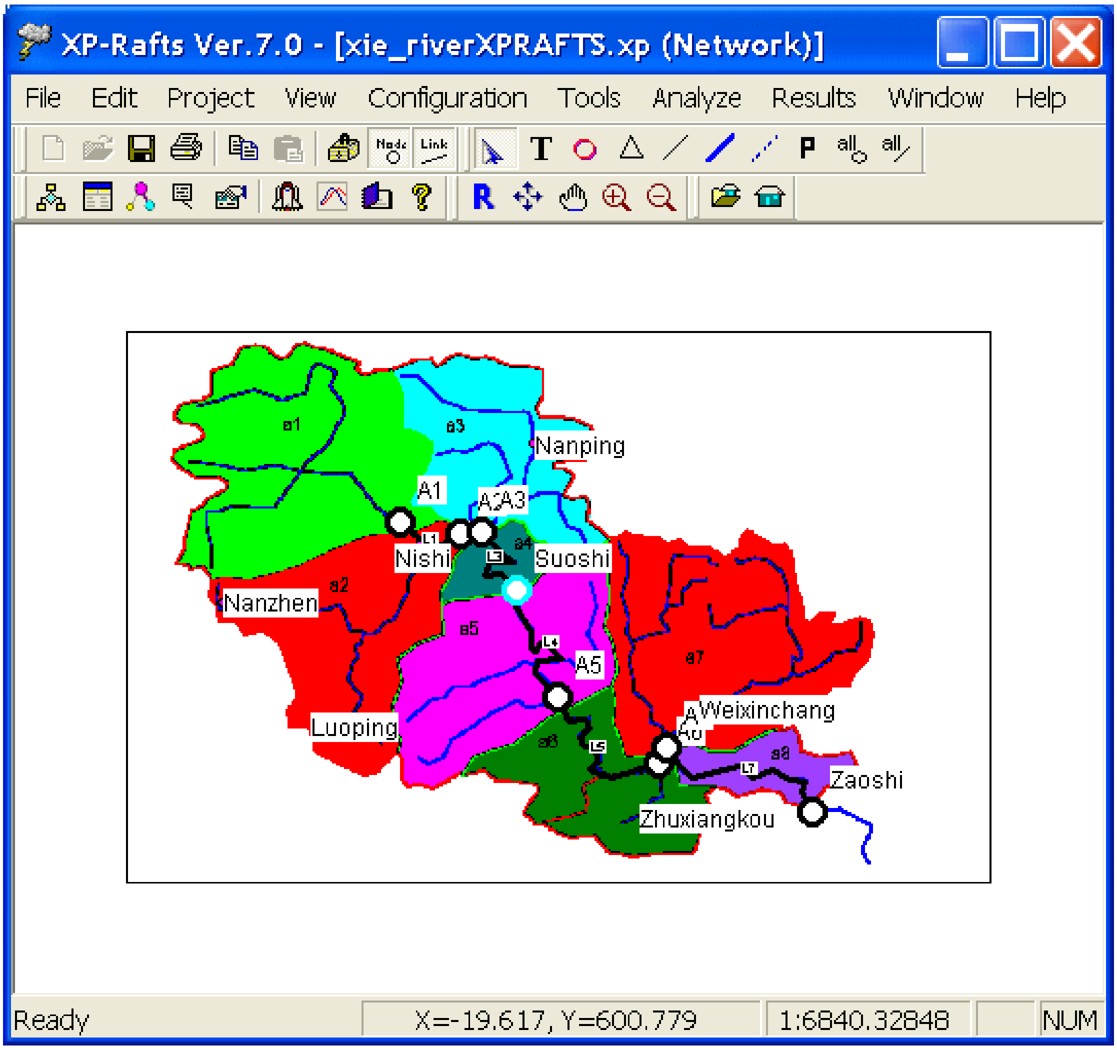
The Icons (The Toolbar)

The Menus

The Pointing Device

The Window

The Window provides the frame of reference for user interaction. The large display area provides a current view of the created network of links and nodes. A Network Overview dialog provides a means of changing the position of the current view of the network. The title of the current database (model) is displayed in the window title bar and status messages describing current program activity such as a description of the function and mouse position are displayed across the bottom of the window.



The Menus

The pull-down menu titles appear on a menu bar displayed underneath the window title. Each menu title represents a group of related commands. If certain commands do not make sense in the current context of what the user is doing, they are disabled and indicated by less prominent and shaded light gray.

The most frequently used commands also have keyboard equivalents, indicated by a keyboard combination such as Ctrl+N (New) listed in the menu. Commands that require more information, typically entered via a Dialog Box, are indicated with three trailing dots after the menu item name.

POP-UP MENUS

THE FILE MENU

THE EDIT MENU

THE PROJECT MENU

THE VIEW MENU

The Pointing Device

The pointing device may be a digitizer, graphics tablet or a mouse. For the sake of consistency we use the term mouse to indicate a generic-pointing device.

Throughout this manual various terms are used to describe functions performed using the mouse. Listed below is a description of the basic mouse techniques used within this program.

Click	Position the pointer on something, and then briefly press and release the mouse button.
Choose	Pick a command by positioning the pointer on the menu name, moving the highlighted area down the menu to the command you want, and then clicking the mouse button.
Drag	Position the pointer on or near something, press and hold down the mouse button as you move the mouse to the desired position, and then release the button. You often do this to move something to a new location or to select something.
Double click	Position the pointer on something, and then rapidly press and release the left mouse button twice
Point	Position the left pointing arrow on or just next to something you want to choose.
Select	Move the cursor to an object, then click or drag across the object.

The mouse pointer changes shape to indicate the type of action that is taking place. The typical pointer icons are described below:

Arrow Icon	You may select objects, move, re-connect or re-scale the network.
Node Icon	Nodes are being added to the network.
Link Icon	Links are being added to the network.
Diversion Icon	Overland flow diversion paths are being added to the network.
Text Icon	Nodes are being added to the network.
Polygon Icon	Lengths or areas are being measured from the network.
Window Icons	A background is being selected or the window is being panned or zoomed in or out.
Hourglass Icon	XP is busy performing a task. The specific task is generally displayed in the status messages area of the window.
Zoom-In Icon	You are currently zooming in to an area of the network.
Zoom-out Icon	You are currently zooming out on an area of the network.

The Mouse allows the user to select objects to operate on by pointing and clicking and similarly to initiate system commands through Pull-down menus.

Icons

Icons

A palette of object symbols (Icons) is provided for the creation and manipulation of objects comprising the network. These toolbars may be turned on and off by selecting Toolbar from the View Menu .

These tools comprise-

Project Icons

File and Print Icons

Tool Icons

Solve & Review Icons

Browse, and Help Icons

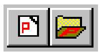
Background Picture Icons

Scaling Icons

Data Icons

Dialog Icons

Project Icons

This Toolbar is only enabled if Projects is enabled in the RAFTSXP.INI file. 

New Project This icon is used to create a new project database.

Open Project This icon is used to open an existing project database.

See Also **Project Menu** .

File and Print Icons

This Icons in this Toolbar have slightly different functions depending on whether Projects is enabled in the RAFTSXP.INI file.

New File This icon is used to create a new database.

Open File This icon is used to **open an existing database**.

Save File This icon is used to **save an existing database** .

Print Network Prints the current view of the network to the default Windows printer.

See Also **File Menu** .and Project Menu

Tool Icons

Pointer Tool This tool is used to select objects, move objects, reconnect links, re-scale the window, change object attributes and to enter data.

Text Tool This tool is used to annotate the network by placing text objects on the network.

Node Tool This tool is used to create nodes on the network. These may physically represent a manhole or pit, an inlet for a catchment. The node shape changes to represent different physical structures. Triangular nodes have storage properties in addition to the system defaults.

Basin Tool This tool is used to create nodes on the network. These may physically represent a manhole or pit, an inlet for a catchment plus a pond or retarding basin or a Best Management Practice (BMP The node shape changes to represent different physical structures. Triangular nodes have storage properties in addition to the system defaults.

Link tool This tool is used to create a lagging link that joins two nodes in a network. This represents a travel time down a reach but not the physical characteristics of the pipe or channel.

Channel tool This tool is used to create a link that joins two nodes in a network. This link represents a

	closed conduit such as a pipe or an open conduit such as a river or man-made channel.
Diversion tool	This tool is used to create a link that defines an overland flow path between two nodes in a network.
Polygon tool	Used to measure the length of a polyline or the circumference and area of a polygon.
Select all nodes	Selects all nodes in the model. Click on the white space to deselect.
Select all links	Selects all links in the model. Click on the white space to deselect.

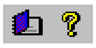
See Also **BUILDING THE NETWORK**

Solve & Review Icons

These Icons provide shortcuts to the more commonly used menu commands.

Solve	Shortcut to the Solve command under the **Tools Menu.**
Review Results	Shortcut to the Review Results command under **the Tools Menu.**

Browse and Help Icons



Browse File	This icon provides a shortcut to the Browse File command under the **Results Menu**
Print Network	Prints the current view of the network to the default Windows printer.
Help	Load the xprafts.chm on-line help (this file!)

Background Picture Icons

The Icons in this Toolbar are used to manipulate any **background pictures** that may be present.

Get Picture	A shortcut to **the Background Images** command in the View Menu.
Picture Properties	Edit the currently selected background picture.

Scaling Icons

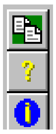
The Icons in this Toolbar are used to change the scale or location of the current view of the network.

Redraw	Regenerates the network without changing the current location or scale.
Fit Window	Re-scales the network to fit the current window (Ft Window)
Pan	Move your view of the network by a user defined offset which is set by selecting this icon and dragging the network from the old location to the new location.
Zoom In Window	Magnify your view of the network by a user defined factor which is set by selecting this icon and dragging a box around the area you wish to see.
Zoom Out Window	Shrink your view of the network by a user defined factor which is set by selecting this icon and dragging a box inside which the current view of the network will fit.

See Also **Network Overview** and Scaling Tools

Dialog Icons

These Icons are present on the right hand side of each dialog. They are used to get information on and to copy individual fields including check boxes, radio buttons and editable text in a dialog.



Copy Data
Used to copy one field within a dialog so that it may be pasted into multiple nodes or links. See also COPY A SINGLE ITEM. Select the item by dragging a box around a text item, radio button or checkbox then select the Copy Icon

Help
Click this button to get help on the current dialog.

Field Information
Used to get information on one field within a dialog so that it may be used in the creation of an XPX file. Select the item by dragging a box around a text item, radio button or checkbox then select the Field Information Icon

Data Icons

These icons provide shortcuts to the global and job control data and also to the data and results presentation options.

Global Data
Shortcut to the Global Data command under the **Configuration** menu

XP Tables
Shortcut to the XP Tables command under the **Results** menu

Graphical Encoding
Shortcut to the Graphical Encoding command under the **Results** menu

Spatial Reports
Shortcut to the Spatial Reports command under the **Results** menu

Job Control
Shortcut to the Job Control command under the **Configuration** menu

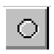
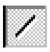
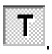
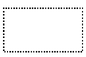
2 - Building the Network

BUILDING THE NETWORK

This section of the manual describes the general philosophy behind the graphical XP environment and outlines the basic design features of this package. It is a good starting point for any new users of any of the XP series of programs.

GRAPHICAL ELEMENTS

The major graphical objects consist of a series of links and nodes. The network of nodes is connected together by links with some additional elements provided for annotation and background reference. The XP environment supports the following types of objects.

Symbol	Name	Description
	Node	Used to represent physical objects such as manholes, inlets, ponds, outfalls or junctions of various links such as natural channels or closed conduits.
	Link	Connections between nodes, they may be physical elements, or only indicative of a connection eg. pipes, channels, overland flow paths, pumps, etc.
	Text	Lines of text used for labelling purposes.
	Picture	Bounded by a dashed rectangle a network backdrop is a pre-defined drawing, created via a CAD package such as AutoCAD®, each background graphic is a single object. Current background graphic types supported include HPGL, DXF and DWG

Each element of the network has certain editable spatial and display attributes and a unique name. Display attributes include the colour and line thickness of the object. Five standard colours are supported; Black, Red, Green, Blue, and Yellow. Three line thicknesses are provided: Thin, Medium and Thick. Spatial attributes include the position and dimensions of the object. Digit images and text notes can also be attached to nodes through the attribute dialog.

CREATING A NETWORK

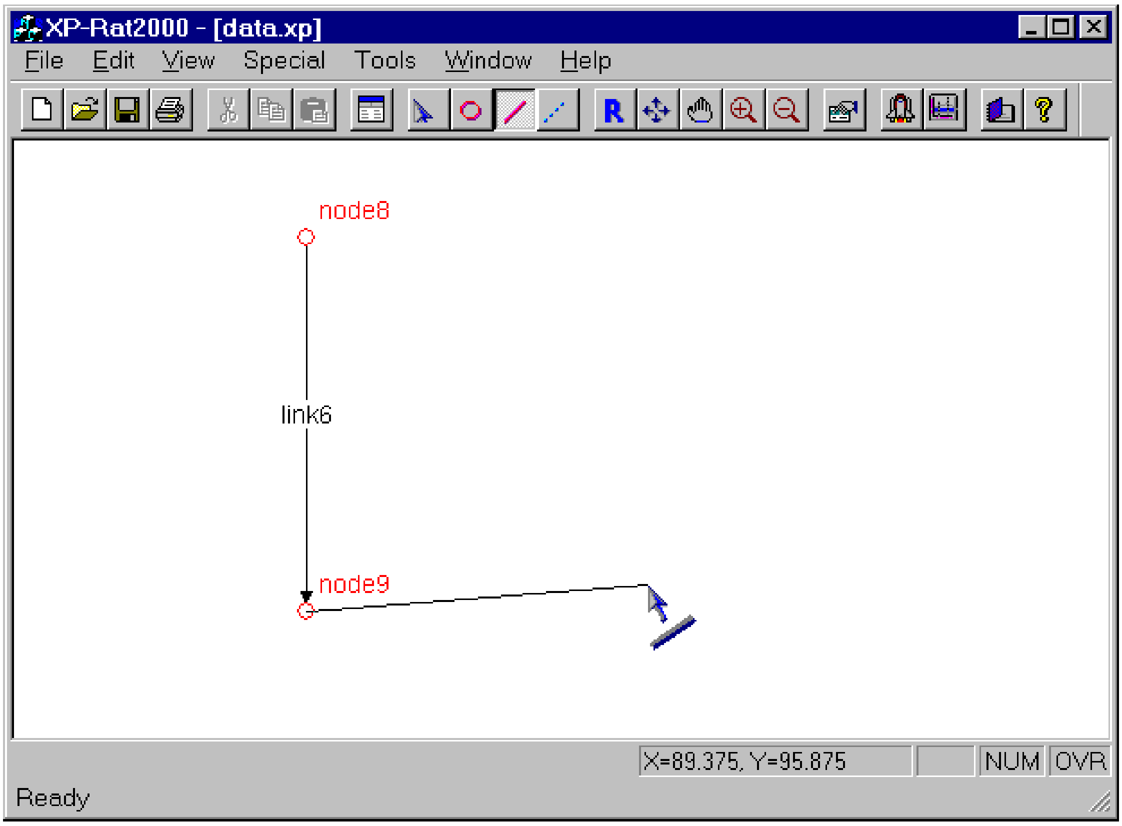
The network is created on the screen using the palette of tools (icons) contained in the tool strip in the window. To create a network, select a node tool from the toolstrip by clicking it. The cursor shape now changes to a node object symbol indicating a node is being created. Clicking in the window now defines the position of the node and creates it and gives it a unique name. The display attributes of the new node (colour and thickness) are the same as those in the toolstrip.

Next, create the links between nodes, selecting the link tool and then clicking on the nodes you wish to connect. The cursor shape again changes to link object symbol indicating a link is being created. A link is directed from the first to the second nodes clicked upon indicating the direction of flow from upstream to downstream. An arrow is placed on the downstream end of the link indicating the direction of positive flow. The position of the second end of the link (the end towards which flows are directed) is indicated by a dotted outline which tracks the mouse movement. A default unique name is automatically created for any object requiring a name.

You may create a polylink (bent link) by holding down the <Ctrl> key as you click with the mouse. This will create a vertex at each point at which you click.

You may change an existing link to a polylink by holding the <Ctrl> key down and clicking at the locations where you want a vertex.

You may remove a vertex by holding down the <Shift> and <Ctrl> keys and clicking on the vertex you wish to delete.



XP performs a series of validity checks to verify a legal network is being created and, if the connection satisfies all of the rules, the link is created.

An additional feature of the link tool is the provision of a default end node. If the link tool is selected and you attempt to create a link in free space, ie. you do not click on an existing node, a default node will be created. In this manner it is not necessary to first create nodes and then join them with links, but rather perform both operations simultaneously.

NAMING AN ELEMENT

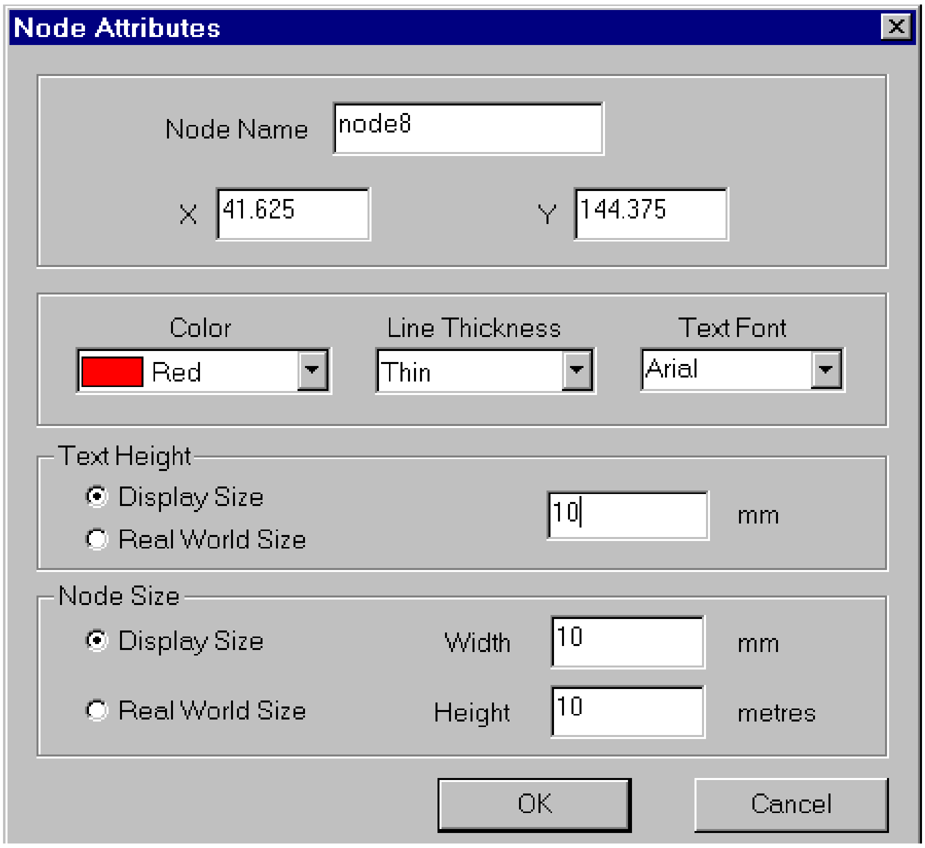
Every object in the network must have a unique name. No node may have a name already used by another node or link in the database. The names are limited to 10 characters. Three methods are available to name a network object, the last two of which invoke the **Attributes** dialog box.

(i) Highlight the node or link then click just below the name and modify the name directly on the screen. Follow the editing with an enter keystroke to terminate editing.

(ii) Highlight the node with the right mouse button and click. This will bring up a pop-up menu. Select **Attributes** to enter the object name in the dialog.

(iii) Highlight the node or link then select **Attributes** from the Edit menu.

If method (ii) or (iii) above is chosen, a dialog box similar to that shown below is then displayed. If the object selected is a link the coordinate boxes are not shown.



Picture File

A bitmap image can be attached to a node by entering the name of a graphics file in the Picture File field. The formats currently supported are BMP, DXF, EPS, FAX, IMG, JPG, PCD, PCX, PNG, TGA, TIF, WMF, WPG, XBMP, XDCX, XEPS, XJPG, XPCX and XTIF.

CREATING A BACKGROUND

Background pictures are special objects that can be created to act as passive backdrop on which the rest of the network may be overlaid.

Pictures are stored in an internal graphics format, as files on disk. These “Picture” files must be present for the background to be drawn. There is neither a limit to the number of background pictures that may be loaded into the network nor to the size of an individual picture.

In general, these objects can be manipulated in the same way as any other network object, with the exception that the <Ctrl> key must be used in conjunction with any other action. Thus, pictures can be selected, deleted, moved, hidden, etc. A picture may be re-scaled isotropically by holding down the <Shift> and <Ctrl> keys.

Three background picture formats are supported: .DWG, .DXF and HPGL/1. DWG and DXF files are supported in their native format. HPGL/1 files must be translated to a .PIC format using the supplied converter CVTHPGL.EXE.

See Also Importing Background Pictures

SELECTING AN OBJECT

Many menu commands operate on the set of currently selected objects. An individual object is selected by choosing the pointer tool from the tool strip, pointing at the object and clicking the mouse button. A selected object is indicated by it being displayed with inverse highlighting.

Groups of objects can be selected by clicking in open space and with the mouse button held down dragging a dotted rectangle around the group. If more than half the object is included in a rectangle the object is selected.

The selections can be extended to include or exclude objects by using the Shift key in conjunction with the mouse button. It has the effect of toggling the state of the object between selected and unselected.

All the objects in the path between two end objects can be highlighted by clicking on the first node (or link), then, with the Ctrl and Shift keys held down clicking on the second node (or link).

MOVING OBJECTS

A selected (highlighted) group of objects can be moved by dragging any object from the highlighted set - the rest will follow. A dotted outline of all affected objects tracks the mouse movements until the button is released, indicating the final position of the moved objects in real time.

RECONNECTING OBJECTS

A link can be reconnected to another node by first selecting it, then positioning the pointer near one end of the link and dragging the end of the link to the new node. A dotted outline tracks the movement of the link in real time. Note: The cursor retains the arrow shape.

Creation of the new link is subject to the same connectivity rules applied during network creation, ie. An illegal network cannot be created through re-connection.

DELETING OBJECTS

A selected (highlighted) individual object or group of objects can be removed from the model by invoking the "Delete Objects" menu command, from the Edit menu. Note: A link cannot exist without both end-nodes; thus when one end-node is removed, the link is also deleted. To delete a vertex from a polylink, hold down the <Shift> and <Ctrl> keys and click on the vertex to be deleted.

A background picture is deleted by first selecting the file with the Select Background tool from the toolstrip. A selected background is connoted with a hatched pattern. Invoking the delete background tool at this point will immediately delete the background.

THE COORDINATE SYSTEM

The screen network is essentially open-ended and unbounded in any direction. The coordinate system has its origin (0,0) at the lower left corner of the opening window and increases to the right and up. In the present implementation, the coordinates are stored in double precision format with up to 20 significant figures to enable the retention of real world coordinates. The coordinates are used in specifying the location of a node, text item, or the bounding rectangle of a background picture.

TRAVERSING THE NETWORK

The network can be traversed by using the <Tab> key starting from any selected link or node. The <Shift-Tab> key or key moves to the previous upstream object.

Alternatively the user may select "Go To ..." from the View Menu and enter the name of the required node or link. The user may specify whether the search is for a node, link or text, or whether the object name is case sensitive or a partial word search.

While employing the multi-selection option successive searches will add to the selection set.

When the user clicks **Find** the requested object name is searched for. If found it is highlighted and displayed in the centre of the screen at the currently selected scale.

PANNING AROUND THE NETWORK

The user can pan by using the Pan tool from the toolstrip. First select the tool and positioning the mouse on a position in the network to pan from. Then drag the mouse while holding down left mouse button to the new location for that point. This moves the entire screen image the distance between the two points in the dragged direction.

While the user is performing this panning function a dotted "rubber" line is displayed showing the distance the image will be moved and the direction.

RE-SCALING THE NETWORK WINDOW

When a network window is re-scaled the size of nodes and labels remains fixed, the nodes being symbols that represent the centre of the object, or the junction of links. When the scale of a picture changes so that the text becomes unreadable it is displayed as a black box showing the location of the text but not the actual characters. The size of the viewed window can be changed in four ways:

The Scale Menu Command

The Scaling Tools

Window Scaling

Fit Window

The Scale Menu Command

The scale factor is a mapping or engineering form of scale with real-world units in metres (or feet). The default scale at which the network of a new database is initially created is 1:1000. This type of absolute zooming is done about the centre of the display window.

The Scaling Tools

Zooming can be performed relative to the current scale factor using the "scaling tools" from the toolstrip. The tools are tied to fixed scaling of 2X for zoom in and 0.5X for zoom out.

Window Scaling

The size and location of a new window can be defined by zooming-in to a rectangle proportioned to the shape of the display window. A rectangle similar to a selection rectangle is created by first selecting the Window Area In Tool from the toolstrip and using the mouse button and dragging a rectangle around the area of interest. When the mouse button is released, the window maps exactly to the proportioned rectangle. Both the size and position of the zoom box can be manipulated in this way.

A zoom-out action may be performed in a similar manner by selecting the Window Area Out tool from the toolstrip and following the above instructions. The dotted rectangle shown on the screen will indicate by how much the current full window will be reduced and where the current window will be shown.

Fit Window

A “world rectangle” is defined as the minimum size rectangle enclosing all objects including background pictures and text objects. The view window can be made to automatically fit the display by giving the **Fit Window** menu command from the View Menu. This function is also embedded in the toolstrip by selecting the Fit to Window tool button.

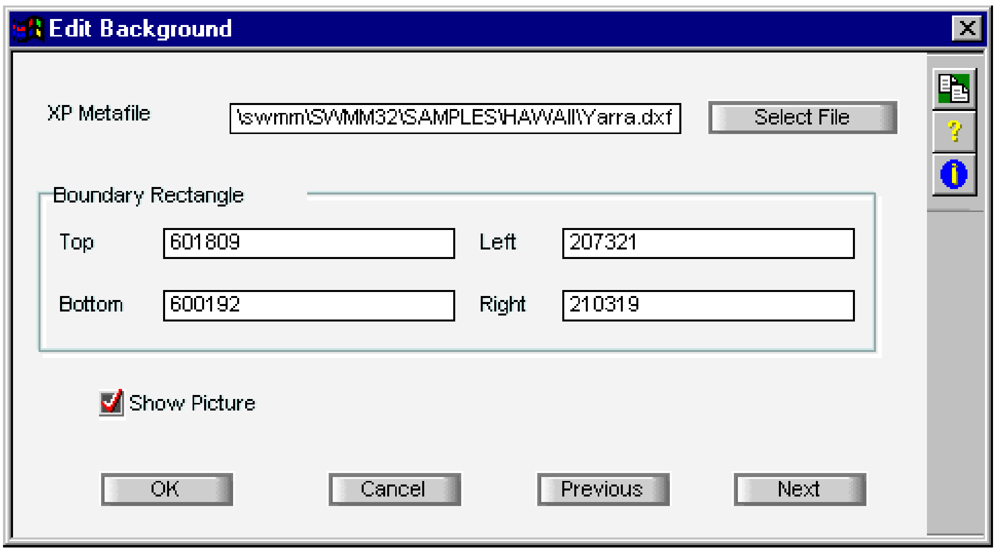
When the window is zoomed in or out, the size of Nodes and Text may remain fixed relative to the screen or may be scaled proportionally depending on whether the "Real-World size" or "Display size" option is chosen as the display attribute. By default the nodes are symbols of fixed screen size representing the centre point of an object or the junction of links.

RE-SIZING THE BACKGROUND

To select a picture, click on the Select Picture Tool from the toolstrip and click anywhere on the picture. The picture will then be highlighted with a hatched pattern to indicate it has been selected. To move a picture first select it, then continue to hold down the left mouse button and drag the picture to its new location. The location where you first clicked is the “hot-spot” of the picture.

To resize a picture, first select the picture. With the mouse drag any of the picture “handles” located in the corner of the picture or in the middle of each of the four rectangular line segments. A dotted rectangle tracks the mouse’s movements and indicates the final size of the picture.

Alternatively the picture attributes, ie. its bounding rectangle, can be modified by highlighting the picture and then selecting the Picture Properties from the toolstrip. This will cause the dialog box below to be displayed and new coordinates may be entered. This dialog also contains a flag to show or alternatively hide the background drawing.



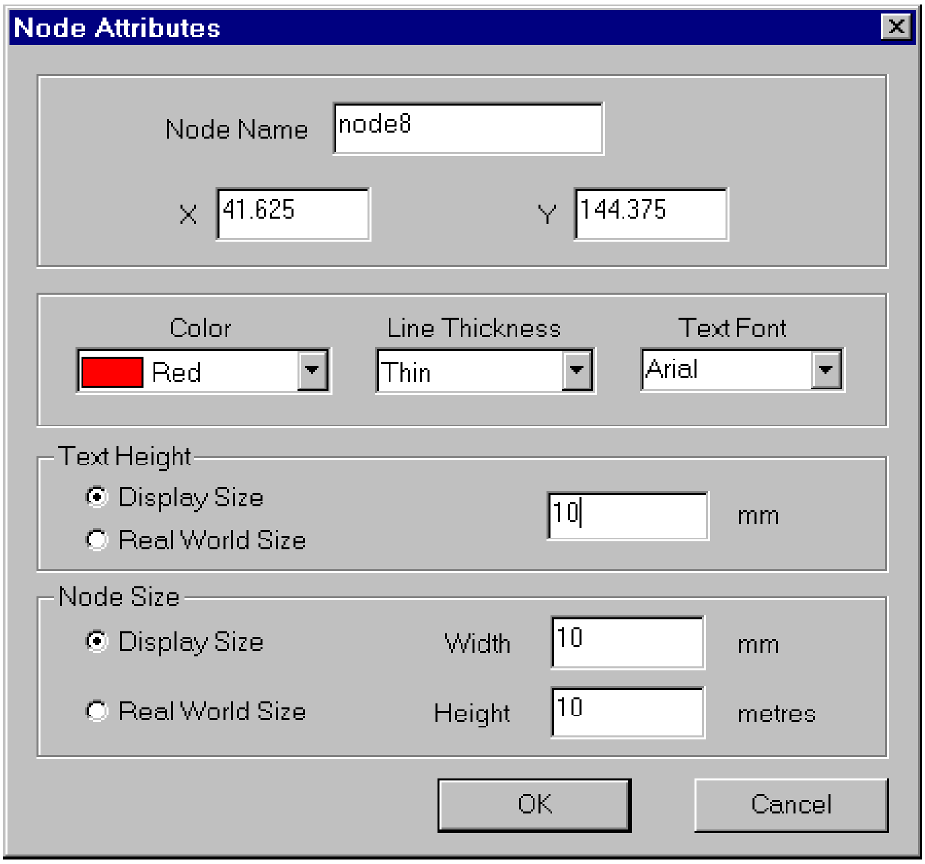
Note that Backgrounds created from DXF or DWG files cannot be moved or re-sized.

RE-SIZING NETWORK OBJECTS

When a large network is displayed on the screen it can appear extremely cluttered. To allow the total network to be viewed (and comprehended) the size of the text and objects may be tied to the scale of the displayed window.

When a group of objects is selected the following dialog boxes are displayed and the attributes such as colour, node and text size etc., may be changed for the selected group of objects.

When OK is selected a dialog similar to the following is displayed (the dialog box shown is for a node selected above)



If Real World Size is selected, the text and object sizes are in real world units. When a scale too small to display is selected the text will be drawn as a box and will only appear after zooming in. If display size is selected, text and object sizes are set in decimal inches or millimetres independent of the scale selected.

The display font may be modified by selecting the corresponding font from a list. A preview of the font is displayed in the Select Font dialog.

Background Images

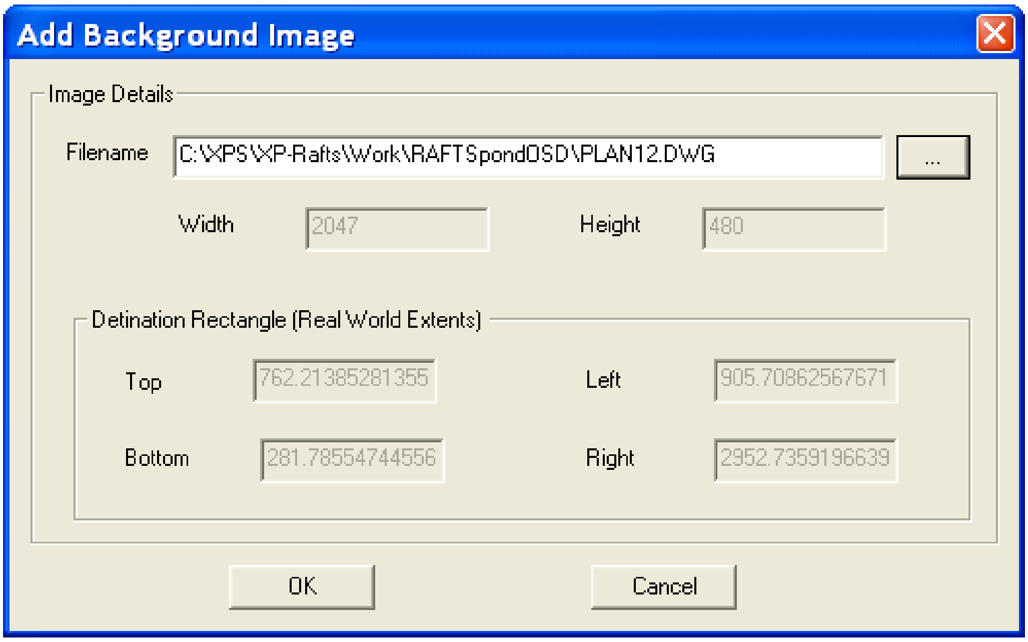
Importing Background Pictures

Background pictures are special objects that can be created to act as passive backdrop on which the rest of the network may be overlaid.

Pictures are stored as files on disk and only a reference to the file and the path is stored in the .XP file. These "Picture" files must be present for the background to be drawn. There is neither a limit to the number of background pictures that may be loaded into the network nor to the size of an individual picture. Pictures can be selected, deleted, moved, hidden, etc

Five background picture types are supported: These include AutoCAD .DWG, and .DXF files, ESRI ArcView Shape files, MapInfo MID/MIF files, digital photos such as .BMP, .JPG, .TIFF. and HPGL (HPGL/1) files which must be translated to a .PIC (a native XP Software format) using the supplied converter CVTHPGL.EXE

To import a background select Background Image from the View Menu or click on the New Background Image tool.



DXF or DWG format:

To load a DWG or DXF file select **XP Metafile** as the file type and then hit the Select button for Input File. The coordinates of the DWG/DXF file will be automatically used.

To create a picture file, a format conversion utility supplied with XP is invoked. This utility converts graphics from HPGL into the internal format used by XP.

Note that Backgrounds created from DXF or DWG files cannot be moved or re-sized.

HPGL/1 format:

The background may also be imported from an HPGL/1 plot file that may be created via most CAD packages, or via numerous design packages that provide output to Hewlett Packard plotters.

To create a background, an HPGL/1 plot file must be generated (from a CAD package, for example). This HPGL/1 file is then converted to the picture format via the “CVTHPGL” utility supplied with XP. CVTHPGL is invoked from the Get Background Menu.

The procedure involved in creating a picture from a CAD package is as follows -

(i) Create the drawing in the CAD package;

(ii) Ensure your CAD package is configured with a Hewlett Packard plotter for output. This must be in HPGL/1 format such as used for HP7580, HP7586, Draftsmaster etc. Newer Inkjet plotters like the HP650C, 700 series etc can be configured to accept input in HPGL/2 format (the default) or HPGL/1 format. This converter cannot use the HPGL/2 format.

(iii) Plot the desired rectangle of interest, noting the co-ordinates of the boundaries. If you wish to retain the scale of your drawing package then the XP destination coordinates must correspond to the top-left and bottom-right corner (extreme points) of the drawing in your drawing package. It is also recommended to import your background picture before creating a database.

(iv) Select Get Background from the Special Menu and choose the HPGL format. When you select OK the “CVTHPGL” program will convert the HPGL/1 file into the internal XP picture format (PIC).

File Type

HPGL

XP Metafile

Input File

Background

XP Metafile

Destination Rectangle

Notes: (1) An error log is created which lists any HPGL commands the program has been unable to translate.

(2) The plotter defaults file "PL_DEF" defines the mapping of pen numbers to colours in a table at the head of the file. The first line of the file contains the number of pens, the following lines contain the mapping of pen number to colour name. Pen number zero, the null pen, must also be mapped to a colour.

This pen colour transformation allows customization for particular CAD packages. See the default file “PL_DEF” included with this program, for details.

(v) Once the HPGL file has been converted to a picture file, it is incorporated into the network as an XP Metafile. The user is prompted for the picture file name and destination bounding rectangle via the Get Background dialog box.

By default, the bounding rectangle fills the display window at the currently selected scale. To maintain the original proportion of the drawing, the user must recall the co-ordinates of the frame originally plotted and use these for the destination-bounding rectangle.

File Type

The two file formats that can be imported are:

(a) XP Metafile - Internal XP picture file format. This is the file format used by XP to store its background pictures.

(b) HPGL - Hewlett-Packard File format. This file is usually created by configuring your CAD program (or other drawing programs) to send the HPGL output to a file instead of the COM port.

The CVTHPGL utility will create a new XP Metafile. The filename of this new file will need to be specified.

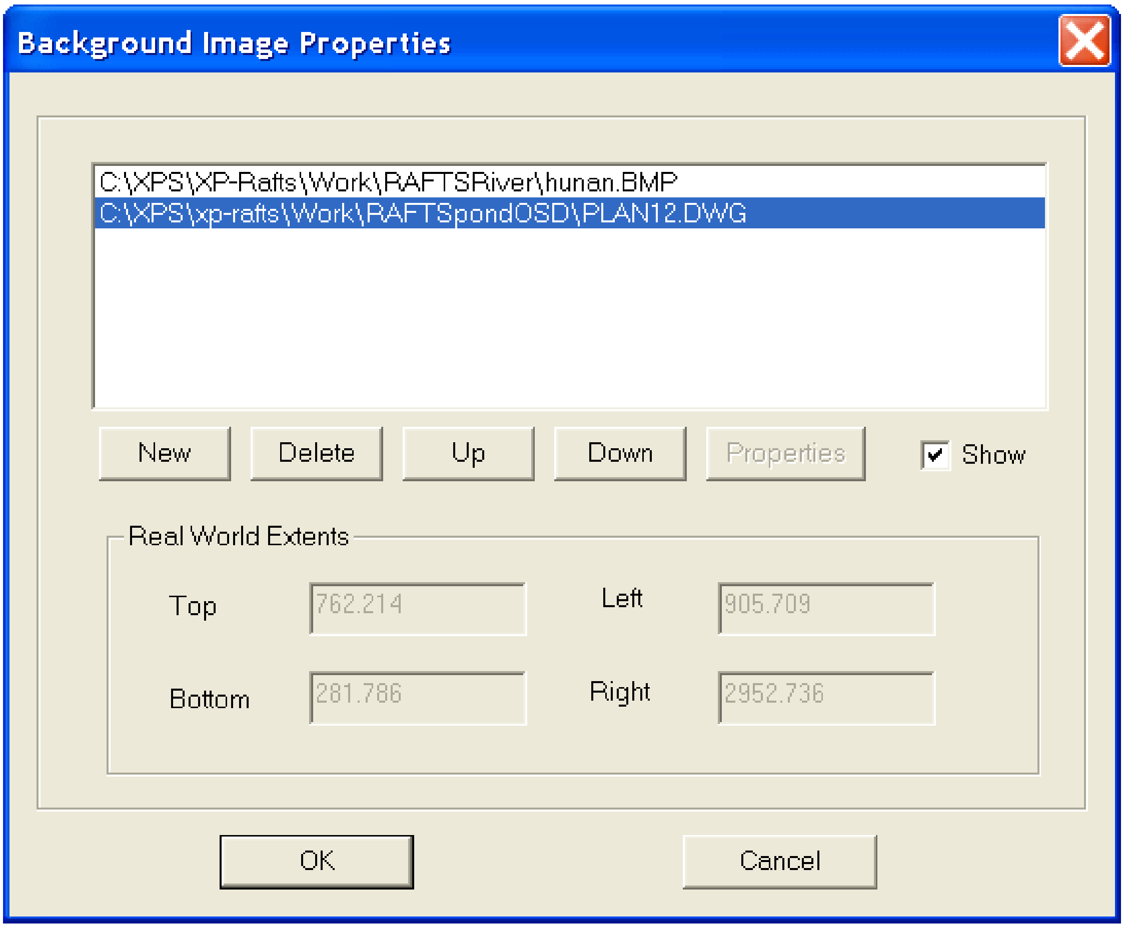
Destination Rectangle

The outer corners (Top, Left, Bottom and Right) where the PICT file will be imported. If importing a HPGL format file then the rectangle corresponds to the edges of your drawing in the drawing package. These coordinates determine the aspect ratio and scale of the imported background.

XP uses double precision coordinates with up to 20 significant figures. This enables map coordinates to be retained. Once a picture has been imported it is treated in the same manner as any other element of the network.

Edit Background

The Background Image Properties dialog is invoked by selecting Background Image → Properties from the View menu or clicking on the Background Image Properties tool.



Show Picture

This check box will enable/disable the background picture.

Previous Picture

This button will show the attributes of the previous background picture.

Next Picture

This button will show the attributes of the next background picture.

Boundary Rectangle

The outer corners (Top, Left, Bottom and Right) where the PICT file will be imported. If importing a HPGL format file then the rectangle corresponds to the edges of your drawing in the drawing package. These coordinates determine the aspect ratio and scale of the imported background.

XP uses double precision coordinates with up to 20 significant figures. This enables map coordinates to be retained. Once a picture has been imported it is treated in the same manner as any other element of the network.

See Also CREATING A BACKGROUND

Hints on Background Picture Creation

The coordinates of a DXF or DWG file will be reset to those of the original file any time the edit background dialog is entered.

When using a HPGL/1 file the prime objective in creating a background picture is to maximise the detail while minimising the size of the HPGL plotter file and hence re-draw performance. Some practical tips:

(i) When generating a plot file from a CAD package, apply any plotting scale factors that minimize the plotted size of the drawing. Remember that HPGL plotters have a resolution of 0.025mm, so that very small plots can still provide reasonable resolution, however, the resolution is coarser with smaller size plots.

(ii) Transform splines to lines if possible. Splines generate lots of plotted points. Transforming spline vertices to Line Polygon vertices dramatically decreases the number of generated vectors while retaining acceptable resolution. This transformation can usually be achieved by exporting the drawing in some text format, editing it, then importing again, eg. DXF format from AutoCAD®.

(iii) Any number of individual files may be imported as background pictures and overlaid or tiled.

(iv) The mapping between plotter pen numbers and picture colours can be altered from the default by editing the plotter default file (by default, PL_DEF) used by CVTHPGL. This will avoid making any modifications to the CAD package configuration.

(v) Minimize the amount of unnecessary text or other drawn objects in the background file. Since text takes more time to draw than most lines this will increase performance and drawing file size.

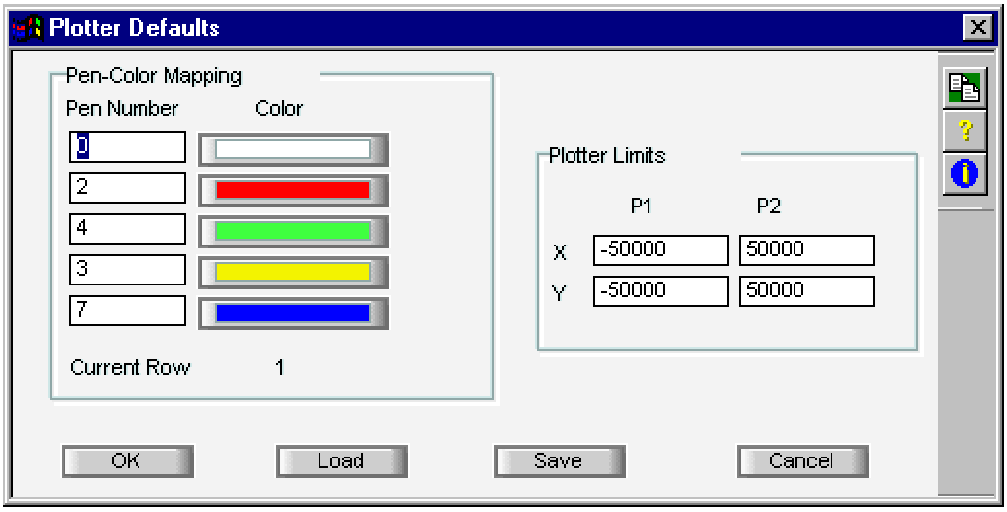
Input File

A PICT filename if importing an XP Metafile file type or a HPGL filename if importing a HPGL file type.

HPGL File Format

Hewlett-Packard File format. This file is usually created by configuring your CAD program (or other drawing programs) to send the HPGL output to a file instead of directly to the plotter.

The CVTHPGL utility will create a new XP Metafile .



Pen Number

HP Plotter pen number that is mapped to a particular color of your choice. Double-click on the color to choose different color mapping.

Pen Color

Color that is mapped to a particular HP plotter pen number.

Plotter Limits

Plotter pen limits in the X and Y directions. These coordinates are in plotter units. The P1 and P2 units should be equal or greater than the plotter units settings of your HP Plotter. To obtain a higher resolution picture it is recommended that the plot be sent to fit the page and the page size be large. If the P1 and P2 limits specified are less than the P1 and P2 settings on your plotter than the background picture will be clipped.

Load Plotter Defaults

This will load the plotter settings (pen mappings and limits) from a file that was earlier saved by the corresponding Save button.

Save Plotter Defaults

This will save the existing settings (pen mappings and limits) to a file.

XP Metafile

Internal XP file format. This is the file format used by XP to store its background pictures.

XP Metafile Output File

Name of the XP Metafile to create in a PICT file format. This is the file that is generated by the CVTHPGL utility.

3 - Database Concepts

DATABASE CONCEPTS

XP maintains an internal database that integrates the spatial data associated with an object with the attribute data required by the model engine.

The graphical network creation and manipulation can be considered as a specialised function dealing with the purely graphical attributes of objects, such as; display symbols, spatial coordinates, and connectivity.

The method of creating the model-specific attribute data is through the Dialog Box.

Database Concepts

THE DIALOG BOX

The Dialog Box is to attribute data what the Window is to the network spatial data. It is a graphical view of the attribute database. The Dialog Box contains different types of items representing different types of data, and is described below:

Static Text Caption for Editable Text.

Editable Text Text strings or numbers. The insertion point for the text is contained in a rectangular field.

Check box A square check box is a flag for a particular option. You may select none, any or all options. A check box with underlying data is located on an action button. Check boxes are always optional.

Choice Button The circular choice buttons (Radio Buttons) indicate a choice of one item from a group of options. Only one option may be selected. A choice button located on an action button indicates underlying data. The selection of one of the choice buttons is mandatory.

Action Button A rectangular action button controls dialog traversal (and therefore data structure). The OK and Cancel Action buttons are usually mapped to the "Enter" and "Esc" keys. A button item in a Job Control Dialog contains mandatory data.

Picture A picture data item is an icon or a symbol used to promote rapid comprehension. It is not a dynamic item and is only representative of typical modeling scenarios.

Picture items are used extensively to symbolise physical attributes associated with the data.

Items are selected by using the mouse to position the pointer at an item then clicking or double clicking with the mouse button. You may also optionally move through the editable text box items by using the <Tab> and <Shift-Tab> keys.

Pressing the Enter key is the same as clicking the OK button.

Pressing the <Esc> key is the same as clicking the Cancel button.

Holding down the <Shift> key while clicking an action button that would normally cascade to an other dialog will only activate the Check Box or Choice Button and not cascade to underlying dialogs.

THE PERMANENT DATABASE

The data managed by XP is permanently stored on disk in a "database" file, an ordinary operating system file. This file should normally have a ".XP" extension.

The database stores both the graphical and non-graphical attributes of all objects in the network, and also the non-specific or general control data associated with a network, such as job title and time steps for the solution procedure, mode of analysis, links to external interface files etc.

THE WORKING DATABASE

To increase the size of networks able to be created and manipulated by XP, the program utilises a combination of memory and disk space to manage data.

In editing sessions, the Permanent Database is not interacted with directly. All changes made are done to an internal working copy of the Permanent Database, known as the Working Database.

The Working Database is established when the Permanent Database is opened. The Permanent Database is updated only when the Working Database is "saved". Copies of the Working Database can be saved under different names at any time, the default name being the name of the Permanent Database when originally "opened".

The Working Database is the active database to which all data editing changes are made. There can only be one active database at any time.

Using the working database provides an error recovery procedure. Since almost all changes to the database are immediately recorded on disk in the working database, catastrophic failures can be recovered from with a minimum of agony. Additionally, if you would like to revert to the permanent database and disregard changes made since the last save, choose Revert from the File pull-down menu.

The working database is named DBxxx where xxx is the next number in a sequence of database files, (typically DB1) and is stored in the directory defined by the TMP or XPTMP system variable or, if none is defined, in the current working directory.

To recover this database, rename it (ie. copy DB1 to FILENAME.XP), then open it as normal.

Note: You are in big trouble if you need to reboot and the temporary directory is a RAM disk.

DATABASE INTEGRITY

As far as possible, data committed to the Working Database via the Dialog Box interface is checked and filtered to maintain the integrity and consistency of the database.

In general, text strings entered by users are the most dangerous type of dialog item because they are a human-readable encoding of some fundamental data type such as a number. This encoding and decoding to and from text strings done by users and computers is a rich source of errors. XP checks all strings at three levels to ensure they can be interpreted correctly.

(i) Absolute Validity. A numerical string, for example, cannot contain invalid characters.

(ii) Absolute Range Checking. Once a numerical string can be interpreted properly, its value is checked for validity in the context of the model, eg. a negative pipe length would not be accepted.

(iii) "Reasonable Range" Checking. If a data item is within the absolute range it is also compared to a reasonable range defined by the Expert Engineer. If the data is between the absolute and reasonable range, the user is asked to confirm that the data entered is correct and is not a typographical error.

These checks are applied to individual data items and are classed as low-level consistency checks. High-level consistency checks are also made, which generally involve placing constraints on relationships between data items. Because these checks rely on the existence of independent data items, often there is insufficient data for XP to perform these high-level checks interactively. These integrity checks are therefore performed off-line at the point of generating the data file for the model to solve.

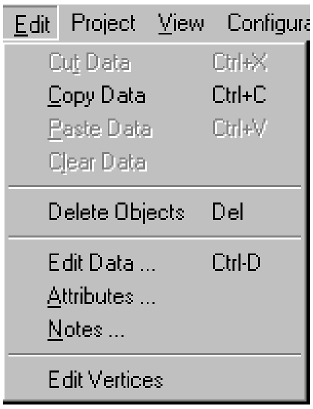
4 - The Copy Paste Buffer

USING THE COPY BUFFER

The XP system uses an internal buffer to move or copy information between dialogs. Data may be “copied”, in which case the original data remains unchanged, or it may be “cut” in which case the data is copied into the copy buffer and then data in the copied object is cleared and reset to its default value.

At present “copying” or “cutting” is restricted to either one item of a dialog or to the entire data structure of a node or link. Data can only be pasted into similar objects ie. node data cannot be pasted into any object except for the same type of node. This is transparent to the user so you may select a multitude of different types of objects before “pasting” and the data will only be pasted into objects of the same type and mode as the parent.

Data within the buffer remains active until the program is ended or another copy command is executed, whereupon the buffer data is overwritten. Data may be copied between databases by closing the current database, opening the new one and then Pasting from the Copy buffer.



COPY DATA FROM A SINGLE OBJECT

COPY MULTIPLE OBJECTS

COPY A SINGLE ITEM

COPYING GLOBAL DATA

Using the Copy Paste Buffer

COPY DATA FROM A SINGLE OBJECT

To copy all of the data associated with a node or link to one or more other similar items in one operation, first select the node or link to be copied and then select “Copy” or "Cut" from the Edit menu. If the copy operation is successful XP then reports how many records have been copied into the buffer. For example:

6 Database Records Copied

To paste the copied data select one or more objects (by holding down the <Shift> key and clicking on multiple objects or by dragging a dotted rectangle around the selected objects) and select “Paste” from the Edit. XP will now report to the screen the number of objects data has been pasted into and the number of records pasted. For example:

3 Nodes (or Links) pasted into

18 Database Records Modified

No Data

COPY A SINGLE ITEM

To copy an individual item, open up the Dialog Box, select the item by dragging a rectangle with the mouse around the field or button. A rectangle surrounding the item indicates it has been selected. Then select the copy icon (Green multi-page) in the upper right hand corner of the dialog to copy the data to the copy buffer. All text items, radio buttons or checkboxes can be copied in this manner

To paste the copied data select one or more objects (by holding down the <Shift> key and clicking on multiple objects or by dragging a dotted rectangle around the selected objects) and select “Paste” from the Edit Menu.

When copying a Text item, the text is checked as if it were to be saved to the database before copying. For Radio Button items, only the active item in the group of buttons can be copied. For both Radio Buttons and Checkboxes with underlying data, only the flag itself and not the whole underlying data structure will be copied. Only single data items can be copied, structures including all underlying data cannot be copied as single items. However, when copying all of the data for an object the underlying data is copied to the copy buffer.

Copy a Dialog List (DLIST) Item

Copy a Dialog List (DLIST) Item

To copy a single cell in a dialog list (DLIST) first move the text insertion point to the cell you wish to copy. Select the text or numerical string by double-clicking or depressing the mouse and dragging over the entire string. Right mouse click to get a Window’s pop-up dialog and select copy from the list. Alternatively using <Ctrl> <C> will copy the selected string. Next move to the text insertion point to the cell where you wish to insert the data and paste the data from the buffer using the right mouse click pop-up dialog or <Ctrl> <V> and repeat as many times as necessary. Only single cells in DLISTS can be copied, there is no facility to copy an individual column or row.

COPYING GLOBAL DATA

Single records of a global database can be copied using the **Copy** button. After opening up a new target database the record is pasted by selecting Paste from the Edit menu. When pasting database records, new records are always created in the current database. If record names clash with existing names, unique names based on the original name and a numerical extension will be generated.

5 - Customizing xprafts

CUSTOMIZING xprafts

The xprafts configuration file **(XP-RAFTS.INI)** provides control over the default behavior of the program, covering aspects such as the memory requirements and optimization strategies. This file is located in your program folder and may be edited with any text editor.

The .ini File

XP-RAFTS.INI FILE

The file format consists of a number of lines of the form:

[Block_name]

VARIABLE=VALUE

BLOCK_NAME is a header for the VARIABLE & VALUE that follows it must be one of: [Main], [Config], [Par], [Settings], [Display], [Status], [Temp] or [Comments].

VARIABLE is not case-sensitive. VALUE is a string of characters relevant to the variable and is also not case-sensitive (see descriptions below). Comments may be included in the file by inserting a pound (#) character anywhere on a line. Any characters on a line following the pound are ignored.

Example:

```
[MAIN]
VERSION=6.0 Sentinel
EDITOR=notepad.exe
TEMPDIR=C:\XPS\XP-Rafts2000\temp
DIRECTORY=C:\XPS\XP-Rafts2000
ENGINE=C:\XPS\XP-Rafts2000\RAFTSENGW.EXE
CNF=C:\XPS\XP-Rafts2000\XP-RAFTS2000.CNF
CVTHPGL=C:\XPS\XP-Rafts2000\CVTHPGL.BAT
HELP=C:\XPS\XP-Rafts2000\XP-RAFTS2000.HLP
WORKDIRECTORY=C:\XPS\XP-Rafts2000\WORK
DBDEF=C:\XPS\XP-Rafts2000\XPDBDEFN.MDB
MSGBOX=C:\XPS\XP-Rafts2000\MSGBOX
APP=RAFXP
[PAR]
MAXNODES=1000
MAXCATCH=750
MAXUSERPIPE=20
MAXRETPER=7
MAXINLETPOINTS=30
MAXOVERFLOWS=5
[CONFIG]
OPT_DB_KEY   = ON
OPT_DB_MEM = ON
OPT_IDX_ACCESS = ON
OPT_DIRTYOBJ =ON
OPT_PART_REC =ON
IO_BUF_SIZE = 4096
```

```
MAX_NODES = 500
MAX_LINKS = 500
MAX_TEXTS = 50
MAX_PICTS = 10
MAX_DBCARDS = 20000
CACHE_SIZE = 16
PROJECTS = ON
DATE_FORMAT = dd/mm/yy
COLOUR=SYSTEM
OPT_RAF_NODE_ADV_BTN=OFF
OPT_RAF_SIMPLE_OSD_ADV_BTN=OFF
OPT_RAF_OSD_ADVANCED=OFF
[STATUS]
FILE1=C:\dev\xp\xp-rafts\Caljan01.xp
FILE2=C:\dev\xp\xp-rafts\data.xp
[TEMP]
[ENGINE]
[WEB]
MAIN=http://www.xpsoftware.com
PRODUCT=http://www.xpsoftware.com/products
```

OPT_DB_KEY

Use: Used for optimizing database searches.

Value: ON (default), OFF - ON enables access optimizations.

Description: This optimization creates a binary tree index of database keys, which significantly decreases the time in searching for database records. The index requires extra memory to operate. If insufficient memory is available, a message will appear whenever a database is created or opened, and the index will not be created.

Memory: About 4k per 1000 database records, or 50k per 1000 nodes.

Comments: Use this option, as memory requirement is small.

OPT_RAF_NODE_ADV_BTN

Use:

Value: ON (default), OFF - ON enables faster access.

Description: This options uses a binary index to access objects internally, speeding access times significantly. No significant additional memory is required.

Memory: None.

Comments:

OPT_RAF_SIMPLE_OSD_ADV_BTN

Use:

Value: ON (default), OFF - ON enables faster access.

Description:

Memory: None.

Comments:
No Data

OPT_DB_MEM

Use: Used for optimizing database I/O.

Value: ON (default), OFF - ON enables a memory load.

Description: The entire database is maintained in memory, generally in expanded or extended memory where available. This option will improve any database access substantially, but requires a large amount of memory. However, the option removes the need for a ram drive to store the database work file, as it is now directly in memory. If insufficient memory is available, a message will appear whenever a database is created or opened, and a work file will be used instead.

Memory: About 130k per 1000 database records, or about 1.5Mb per 1000 nodes.

Comments: Use this option if extended/expanded memory is available.

OPT_REDRAW

Use: Optimizing network redraw by restoring screen image.

Value: ON (default), OFF - ON enables image restores.

Description: Network display can now occur in two ways: regeneration or restore. Regeneration is the mode used up to now, which causes every network object's display to be regenerated when the network window is redrawn. Restore mode restores a saved bit-mapped image of the network window, which takes a constant amount of time and is much quicker than a regenerate, but requires more memory. Restore is used as much as possible when the network window needs to be updated. The Redraw menu command now forces a regeneration to occur. If insufficient memory is available, a message will appear the first time a database is opened or created, and the option will be disabled.

Memory: 1 byte per screen pixel; for VGA(640x480), 300k.

Comments: Use this option if extended/expanded memory is available.

OPT_IDX_ACCESS

Use: Optimize internal access to network objects.

Value: ON (default), OFF - ON enables faster access.

Description: This options uses a binary index to access objects internally, speeding access times significantly. No significant additional memory is required.

Memory: None.

Comments: Always use this option.

OPT_DIRTYOBJ

Use: Optimize saving of network objects.

Value: ON (default), OFF - ON enables saving of dirty objects only.

Description: Only saves the nodes & links that have been altered - this optimizes saving the network. An internal flag is maintained for each object which indicates if the object's graphical attributes have altered from the time the database was opened.

Memory: None.

Comments: Always use this option.

IO_BUF_SIZE

Use: Optimize database temporary buffer transfer times.

Value: 0 - 32767 (4096 by default).

Description: The size of the temporary database file buffer (in bytes). This option allows the user to speed up database loads and saves by setting the size of the temporary file buffer. There is an optimum size which depends on the local file system. If insufficient memory is available, a smaller buffer size will be used.

Memory: The buffer size, but allocated dynamically during the Load or Save operation.

Comments: Always use this option, as the memory requirements are transient. The default buffer size should provide reasonable performance for most file systems.

OPT_PART_REC

Use: Optimize database record I/O by accessing partial records.

Value: ON (default), OFF - ON enables accessing partial records.

Description: Internally, accessing a database field always required accessing the whole record first. This optimization allows accessing any field within the database record directly, saving the amount of data transfer required.

Memory: None.

Comments: Always use this option.

MAX_NODES

Use: Set the maximum number of nodes for the network.

Value: 0 - 32767 (10 by default).

Description: Sets the maximum number of nodes that the XP network can contain.

Memory: Approx. 250k per 1000 nodes.

Comments: This value if set beyond the licensed value will be reset automatically.

MAX_TEXTS

Use: Set the maximum number of text strings for the network.

Value: 0 - 32767 (20 by default).

Description: Sets the maximum number of text annotation objects that the XP network can contain.

Memory: 250k per 1000 texts for the extended version.

150k per 1000 texts for the standard version.

Comments: None

MAX_PICTS

Use: Set the maximum number of background pictures for the network.

Value: 0 - 32767 (20 by default).

Description: Sets the maximum number of background picture objects that the XP network can contain.

Memory: 130k per 1000 pictures for the extended version.

110k per 1000 pictures for the standard version.

Comments: None

MAX_LINKS

Use:	Set the maximum number of links for the network.
Value:	0 - 32767 (10 by default).
Description:	Sets the maximum number of links that the XP network can contain.
Memory:	Approx. 250k per 1000 links for the extended version.
Comments:	This value if set beyond the licensed value will be reset automatically.

MAX_DBCARDS

Use:	Set the maximum number of database records.
Value:	0 - 200000 (10 times MAX_LINKS by default).
Description:	Sets the maximum number of database records that XP may contain at any time.
Memory:	6k per 1000 database records, or about 10k per 1000 nodes. There is an additional work file requirement of 130k per 1000 database records, or about 1.8Mb per 1000 nodes, which is a disk file requirement normally, but may be a direct memory requirement if OPT_DB_MEM is ON.
Comments:	None

DATE_FORMAT

Use: Used for defining a country-specific format for date.

Value:

MM-DD-YY	month-day-year format
DD-MM-YY	day-month-year format
YY-MM-DD	year-month-day format

Two digit numbers must be supplied for days and months. Years may be two or four digit. If years are two digits, the 20th century is assumed. The separator between digits may be any non-digit character, so that the first format could be entered as mm/dd/yy which requires a forward slash character to be used as the separator in the actual date.

Description: The definition is used to configure the program for various countries. Any date entered in a dialog must conform to the format defined by this variable.

Memory: None.

Comments: Year 2000 compliance requires 4-digit year entry. This variable is not usually modified.

CACHE_SIZE

Use:	Set the size of a special database cache.
Value:	0 - 32767 (16 by default).
Description:	Sets the maximum number of database records in a special cache that XP may use. The special cache optimizes database record access by reducing the number of file transfers required to the database work file.
Memory:	130 bytes per cache record.
Comments:	None

APP_FLAGS

Use:	Change the configuration of XP-SWMM.
Value:	“” (default), “E” - EXTRAN Mode only, “M” - Malaysian Mode (Int’l only), “U” – UDD Only.

Description: Restrict XP-SWMM32 to EXTRAN, UDD or enable the Malaysian Hydrology.

Memory: None.

Comments: None.

PROJECTS

Use: Allow grouping of XP files into projects of up to 100 files.

Value: ON (default), OFF

Description: See THE PROJECT MENU .

Memory: None.

Comments: None.

EDITOR

Use: Default Editor used by Browse and for reporting errors and warnings.

Value: NOTEPAD.EXE (default), or any text editor.

Description: The editor used when the Browse menu command is used for viewing text files and for reporting errors and warnings. EDITPAD.EXE and NOTEPAD.EXE (Notepad+), “postcard-ware” programs are automatically installed but must be selected by the user, you can also used Wordpad, Word, Word Perfect, etc..

Memory: Program dependent.

Comments: None.

TEMPDIR

Use: Location of temporary files.

Value: The name of any directory.

Description: Used to locate the temporary files such as the DB, XP, ZZ etc. files.

Memory: None.

Comments: None.

ENGINE

Use: Change the engine used by XP-Rafts2000.

Value: RATENGINE.EXE (default). Including the full path to this file.

Description: By default XP- Rafts2000 uses RAFTSENGINE.EXE as its engine (invoked when solve is selected).

Memory: None.

Comments:

DIRECTORY

Use: Location of home directory or installation directory.

Value: The name of any directory.

Description: Used for files such as the XP, BAK, SYF, SYT, SYR OUT etc. files used by the model.

Memory: None.

Comments: None.

File Extenstions

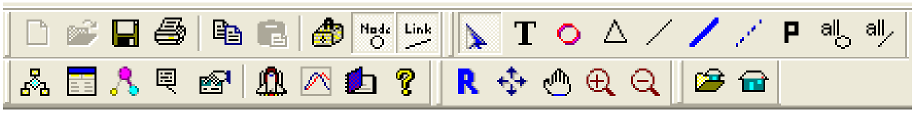
FILE EXTENSIONS

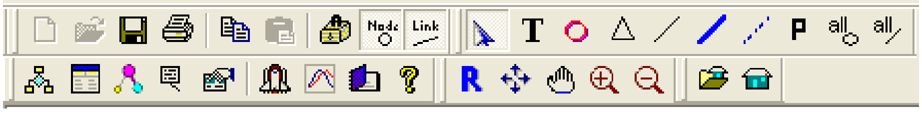
xprafts uses the following file naming conventions:

DB??	The working copy of the xprafts database. This file is located in the directory pointed to by the TMP or XPTMP environment variable. This file is normally deleted when you Quit from xprafts.
XP??	A snapshot of the current state of the working database (DB file). It is created when xprafts runs another program, eg. to Solve, Review Results or Plot. This file is normally deleted when XP- xprafts is re-opened.
LOCK	A file used. This file is deleted upon termination of the child process.
MSGBOX	The message box used to transfer executions between modules. This file is deleted upon termination of the child process.
*.XP	The main database. This file is updated whenever Save is selected.
*.XPP	The projects database. This file is updated whenever Save is selected.
*.XPX	A text file in the XP eXchange format for import and export.
*.OUT	The text output file generated when a database is solved.
*.RPT	An optional condensed output file generated when a database is solved.
*.RES	An intermediate results file used by xprafts.
*.PLT	An intermediate results file used for plotting.
*.SYF	An intermediate results file used for plotting and for reviewing results (Hydraulics).
*.SYB	An intermediate results file used for reviewing results (Hydraulics).
*.EPD	An plot definitions file.
*.PIC	Background pictures or a file generated by Export Graphics.
*.DXF	An AutoCAD® drawing file.
*.SCR	An AutoCAD® Script file generated by the Export Graphics menu command.
*.MOD	Mode setup file.
*.SRP	Spatial Report Setup file.
*.GEN	Graphical Encoding Setup file.
*.RDF	Report Setup file.
*.DEF	Profile Plotting Setup file.

6 - Toolstrip Icons

THE TOOLSTRIP ICONS





A palette of drawing tools (icons) is provided for the creation and manipulation of objects of various types.

When the mouse is clicked inside one of the tools a number of things happen -

- any selected objects are de-selected,
- the tool beneath the mouse becomes current and is highlighted,
- the mouse cursor changes to reflect the current tool.

This section of the manual describes the function and use of each of the available tools.

POINTER

TEXT

NODE

LINK

SCALING TOOLS

See Also Icons

POINTER

At the network level the Pointer tool is used specifically to manipulate the current selection, move the current selection around, reconnect links and for re-scaling. At the dialog level it is used to select a data item or to position the cursor for editing text.

The "current selection" is the set of objects which many menu commands operate upon. Objects that are members of a selection are indicated in inverse video (bright magenta). To make a single object the current selection, just point to it and click.

To select a group of objects in a single operation the mouse button is held down and the dotted outline of a box is dragged around the desired group. To deselect everything, the mouse is clicked in open space. All the objects in a path between two nodes can be selected by first clicking on one node, then, with the <Ctrl> key held down, clicking on the other end node.

To extend a selection, the <Shift> key is held down in conjunction with the selection operation. The <Shift> key causes new selections to be toggled. The only exception is Background Picture Objects which must be modified while holding down the <Ctrl> key.

Moving Objects

Reconnecting Links

Moving Objects

To move a group of objects, they are first selected using one of the methods described above. The pointer is then positioned on one of the items and the mouse is dragged to a new position with the mouse button held down. This displays a dotted outline of all affected objects while tracking the mouse's movements. When the mouse button is released, all affected objects assume their new positions.

Note that if a link is moved both its end nodes are affected.

Reconnecting Links

To reconnect one end of a link to another node, first select the link, then pick a point on the link near the end to be moved and drag it to the new node.

No Data

NODE

The node tool represents an object located at a point and is the point of connectivity between links in the network. Selecting the node tool changes the cursor to the cross-hair shape shown above and places you in a mode for creating node objects. Clicking anywhere inside the window will create a new node at that point with display attributes identical to those of the node tool shown in the toolstrip.

XP uses a node tool to represent a junction of links and also as the point of input for the local catchment within the drainage network.

LINK

A link is defined as a connection between two nodes. Links cannot exist without nodes at the end points, and have a sense of direction indicated by an arrow.

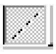
When a link tool is selected, the cursor changes to a cross-hair, and the user is in a mode for creating links between nodes. The first click in the window defines the node from which the link emanates. The next and subsequent mouse clicks identify the node to which the link joins. A straight line is then drawn between these two nodes with an arrow indicating direction.

If the mouse is not clicked on an existing node, then a default node is created at that point for the new link. Following each mouse click in the drawing area, a dotted line tracks the mouse's movements, indicating how the new link will appear. This is the most effective way of creating a new network.

The successful creation of a link depends on certain network validity checks made by the XP shell, described in Section 12: EXPERT SYSTEM CAPABILITIES .

XP-RAFTS uses three types of links

Conduit Link



Diversion Link

The conduit link represents a drainage path between nodes such as a circular pipe, rectangular pipes, or open channels of any cross section.

The multiple conduit/diversion link represents either an alternative flow path between nodes, such as a weir, an orifice or a pump, or allows you to have a number of conduits between the same two nodes without the need for dummy nodes.

Polylink

Polylink

A polylink is a special type of link that has vertices between the two end-nodes. It may be used to define the path of a river, or to indicate a curved pipe, or in any situation where the end-nodes are not connected in a straight path. To create a polylink, select the link tool as normal and hold the <Ctrl> key down while clicking at the location at which you want a vertex.

An existing link may be converted to a polylink by holding down the <Ctrl> key and clicking on an existing highlighted link. To re-shape a link drag the vertex of the highlighted link to the new location and release the mouse button. To delete a vertex hold down the <Ctrl> and <Shift> keys and click on the vertex you wish to delete.

Note that the network may be re-scaled or panned without the need of re-selecting the pointer tool. See PANNING AROUND THE NETWORK and RE-SCALING THE NETWORK WINDOW for more details.

SCALING TOOLS

The scaling tools are used in addition to the View menu commands to zoom in or out. They are commands in disguise, rather than real drawing tools. Scaling may be accomplished by clicking on the tool with the mouse button to "pop–up" the menu shown below, and then directly selecting the desired scale factor.

Unlike the View menu these scale factors are all relative to the current screen scale.

Larger scale factors will zoom-in to the network; smaller scale factors zoom-out. Zooming is done about the centre of the display window.

To zoom in to a small rectangular region, hold down the <Shift> key and the right mouse button and drag a dotted rectangle around the area to be enlarged or alternatively use the .Scaling Icons .

The shape of the box is proportional to that of the current window so that the region zoomed in to will map exactly up to the size of the display window when the mouse is released. Both the size and position of the zoom box can be manipulated in this way.

The reverse procedure, ie. scaling down (or zooming out),can only be performed by using the .Scaling Icons . The dotted rectangle shown on the screen indicates the size the current window will be shrunk to when the mouse is released.

See Also Scaling Icons and Network Overview

7 - Menus

THE MENU BAR

The menu bar displays the titles of eight menus. Four of the menus, File, Edit, Project, View, Special, Window and Help are common to all systems utilising XP. The Tools menu is specific to the application, in this case XP-Rafts. Whenever you work with XP you enter commands by pointing to a menu, then dragging down to highlight the command you want. Any commands in the menu that are disabled are displayed as greyed-out. A disabled menu item indicates that the command is not available in the current context, and that some other action is required before it can be invoked.

As a short cut, keyboard equivalents are available for the most frequently used commands. The keyboard equivalent is indicated by an underlining "_" of the letter appropriate to this command. To invoke commands from a menu use the <Alt> key in conjunction with the character, for example <Alt-F> to invoke the File menu. Once the menu is displayed press the underlined character of the menu to select the command, for example X to Exit. Some commonly used commands use the <Ctrl> key in conjunction with the appropriate menu command as an additional shortcut, for example <Clrl-O> to open a new file.

Menu commands that are followed by a dialog box are indicated by an ellipsis "..." after the menu item name.

POP-UP MENUS

THE FILE MENU

THE EDIT MENU

THE PROJECT MENU

THE VIEW MENU

THE CONFIGURATION MENU

THE TOOLS MENU

THE ANALYZE MENU

THE RESULTS MENU

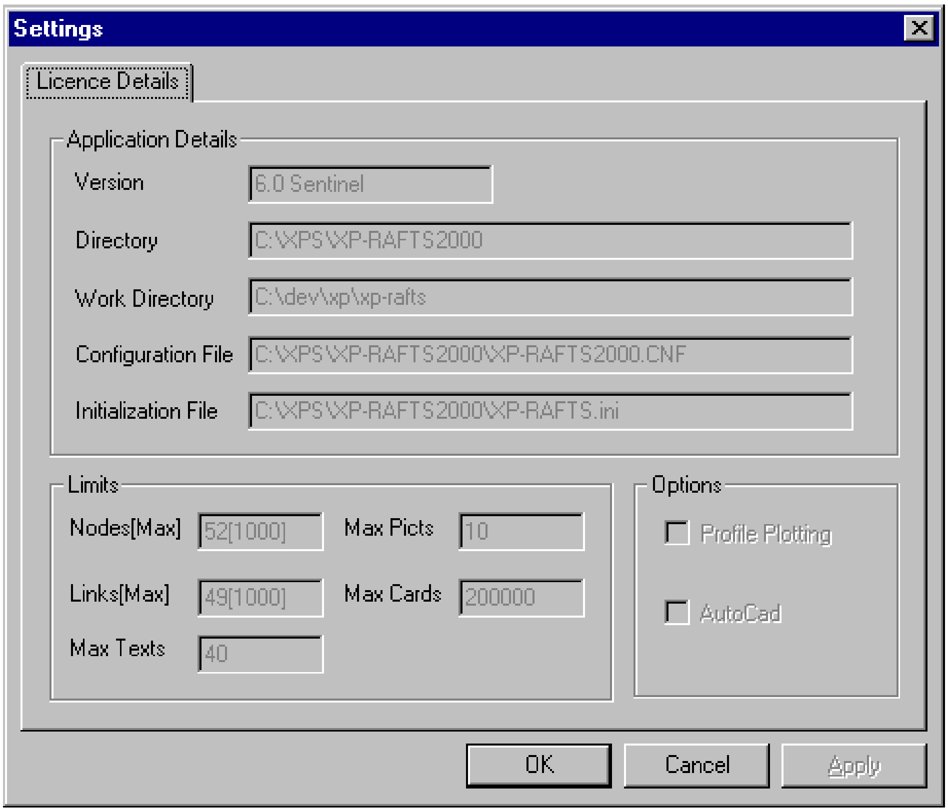
THE WINDOWS MENU

THE HELP MENU

All Nodes

All Links

Settings



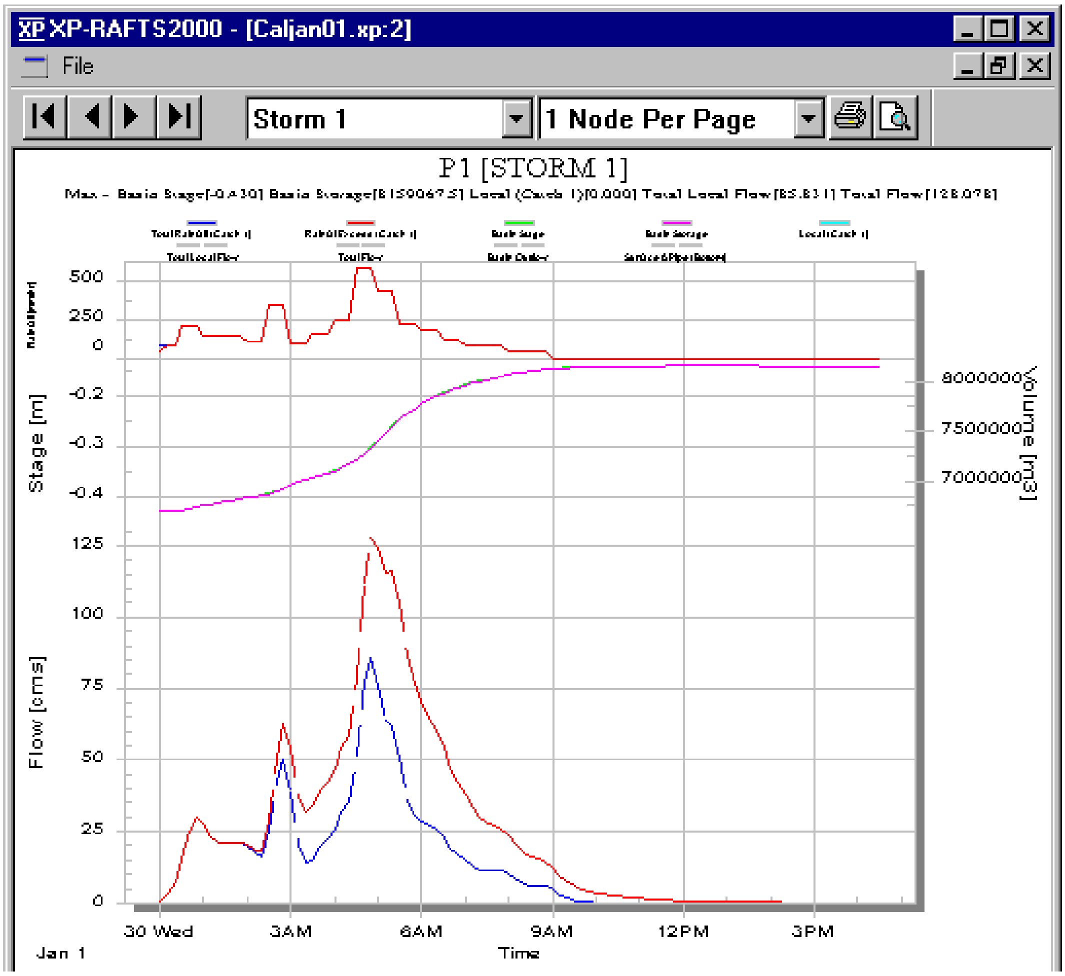
Export To DXF

Calibrate Model

Encrypt for Viewer

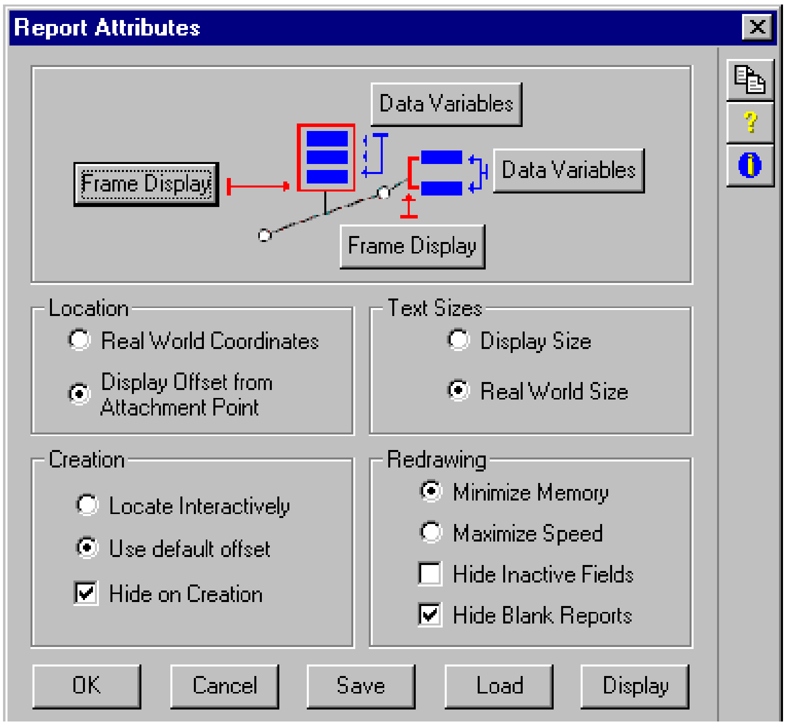
Review Results

This function provides graphical post-processing of the XP-Rafts2000 analysis. A display of data and hydraulic results on a reach and node is provided. To use this feature select all of the links and/or nodes you wish to examine, if necessary using the <Shift> key to extend the selection then select Review Results from the menu.



Spatial Report

This command allows you to specify the display format of the Spatial Reports by selecting the physical attributes of the reports and the data to display in each report. This dialog specifies data for all the reports.



Frame Display (Nodes)

Frame Display (Links)

Data Variables (Nodes)

Data Variables (Links)

Location

Text Sizes

Creation

Redrawing

Save

Load

Display

Location

These two radio buttons define the location of the spatial report data.

Real World Coordinates

When you select this option, the location for each report box is fixed in the coordinate space of the network. This means that a change of scale affects the position of each report on the screen, but not on the coordinate plane.

Display Offset from Attachment Point

When you select this option, the location for each report box is a given offset from the attachment point to the relevant object. The offset is independent of the scale of the displayed network.

Note: These items can be used to modify the relative offsets of the Spatial Reports. To do this:

(i) Set the location to real-world coordinates then hit OK.

(ii) Zoom in or zoom out your network view until the attachment lines are an acceptable length.

(iii) *Open the Spatial Reports dialog and set the location to display offset.*

(iv) *Return to the network window and the Spatial Reports should be correctly displayed. If not then repeat this procedure.*

Text Size

Display Size

With this option selected the text size is shown in a constant size (mm or inches) regardless of the scale selected.

Real World Coordinates

When this option is selected the text will be shown relative to the scale of the drawing. As you zoom in the text will get larger.

Creation

When new nodes or links are created the location of the Spatial Reports is controlled using the options described below.

Locate Interactively

When this option is on, the user defines the location of the Report Boxes interactively when the Nodes or Links are created.

Use Default Offset

When this option is invoked, the reports are created in a default location, as opposed to you explicitly placing them.

Hide on Creation

When you select this option, the Reports are hidden when a Link or Node object is created. Otherwise, the Reports are displayed as they are created.

Redraw

Redraws the current screen. This command is useful for cleaning up a messy display following some object movements such as Pasting objects and when calculating areas and lengths using the polygon tool.

Save Report

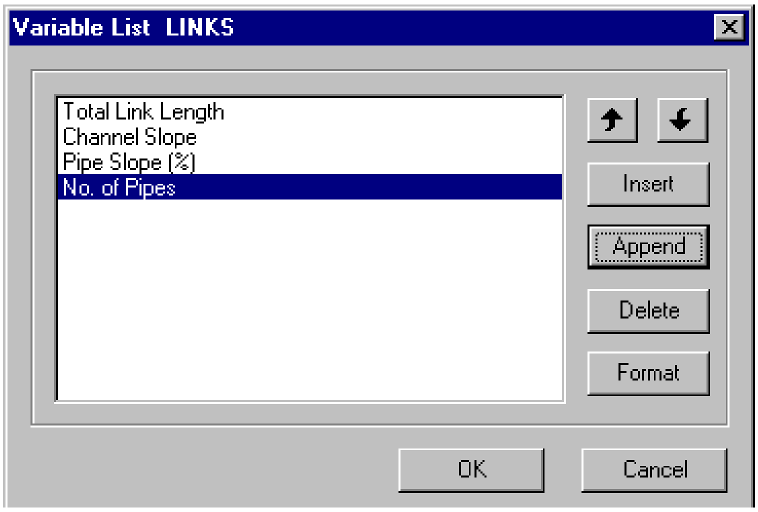
This button saves the report settings to a user - specified file. All the global attributes excluding the flags on this dialog are saved.

Load Report

This button loads the report settings from a user-specified file. All the global attributes excluding the flags on this dialog are loaded.

Data Variables (Link)

This button loads the Data Variables dialog which allows you to select the data fields you wish to display in the Spatial Report for Links. The list displayed in the following dialog contains the names of all data items that will be included in your spatial report for links.



Insert/Append

Delete

Format

Delete

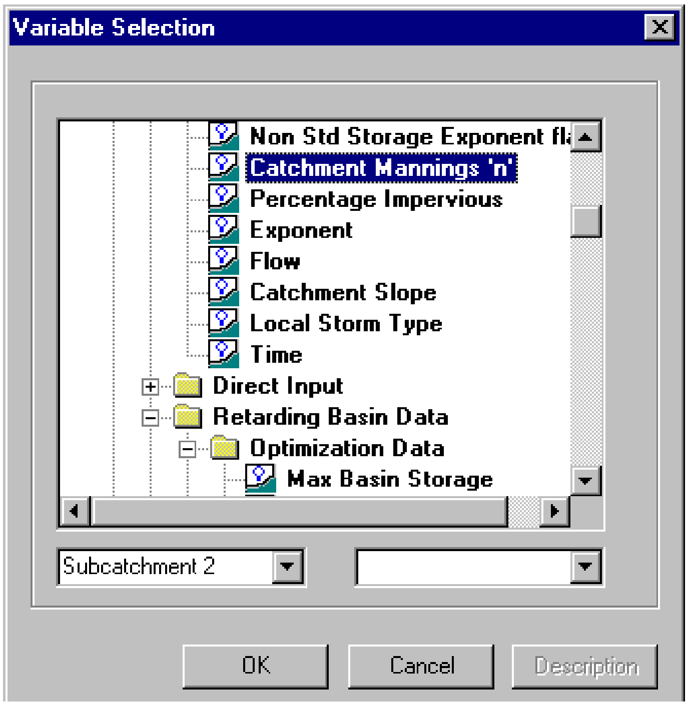
The delete button removes a report data variable from the list.

Insert/Append

These buttons allow you to insert a report data variable before the highlighted field in the list or at the end of the list respectively.

When you select either of these buttons the following dialog showing all available data is displayed. When OK is selected the highlighted field is added to the list shown in the preceding (parent) dialog.

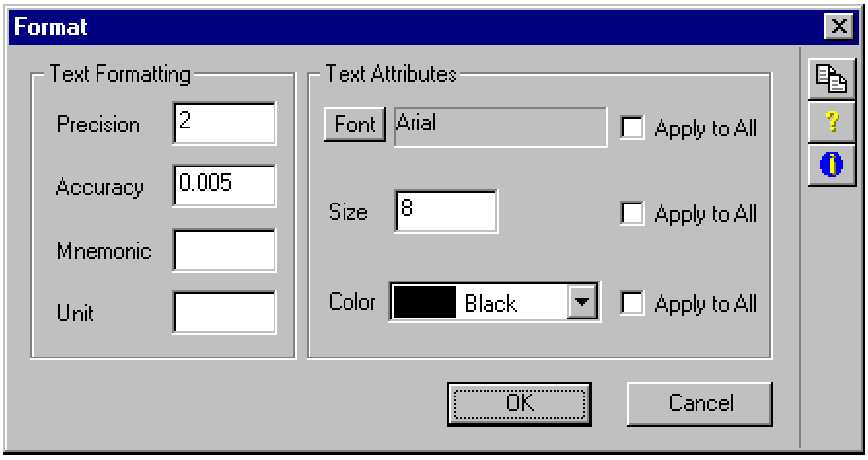
If the variable selected has multiple instances (ie. Conduits, Pumps, etc.) then a combination of Variable and Instance must be selected. To show all instances of a selected variable all combinations of Variable: Instance must be selected.



Format

This button takes you to a format dialog which allows you to select the format of the highlighted variable (the format specification is always attached to the data variable, even when that variable is removed from the list).

The description of the variable to be formatted is shown in the title bar of the dialog.



Text Formatting

Text Attributes

Text Formatting

Precision

This value specifies the number of places after the decimal point to display on the Spatial Report.

Accuracy

This value specifies the tolerance of the displayed data.

Mnemonic

This allows you to add a mnemonic to the start of each line of data displayed in the Spatial Reports.

Unit

This allows you to add a unit to the end of each line of data displayed in the Spatial Reports.

Text Attributes

Font

This allows you to specify the font in which you wish to display the currently selected variable of the Spatial Report. The normal Windows conventions regarding bitmap and true type fonts are supported.

Apply to All

If this checkbox is enabled then this font style will be applied to all the spatial report data for nodes.

Size

The height of the text (in mm) in the report line is entered here.

Apply to All

If this checkbox is enabled then this font size will be applied to all the spatial report data for nodes.

Text Colour

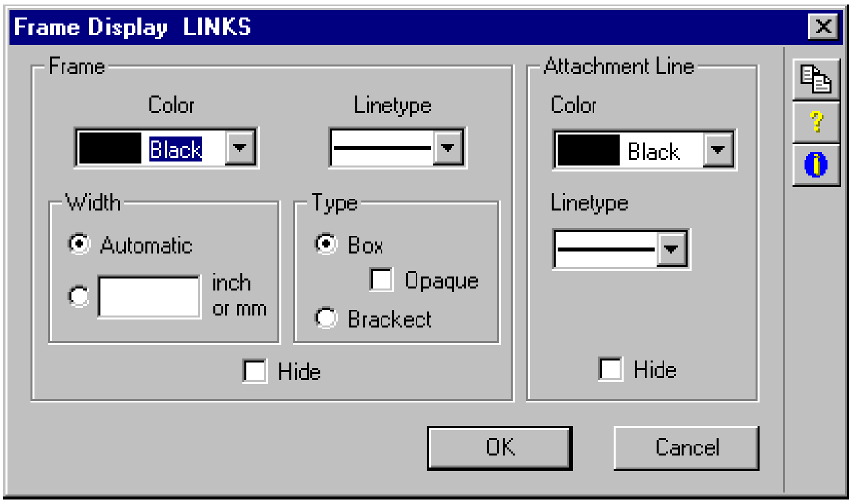
These buttons allow you to set the colour of the report text.

Apply to All

If this checkbox is enabled then this font colour will be applied to all the spatial report data for nodes.

Frame Display (Links)

This button loads the attributes dialog and allows you to specify such things as box colour and attachment line colour for Spatial Reports for Links. The type of frame used by the link data and the form of the attachment line may be modified from within the following dialog.



Frame

Attachment Line

Frame

Colour

These buttons allow you to change the colour of the box surrounding the reports attached to nodes.

Line Type

These buttons allow you to change the line type of the box surrounding the reports attached to nodes.

Width -

These options control the size of the box surrounding the Spatial Reports.

Automatic

When you select this option, the size of the surrounding box is calculated automatically by maintaining a border around the text. The size of the box is calculated assuming DXF MONOTXT font will be used for hard copy output.

Box Width

If you turn Automatic off, then a value entered here will specify the minimum width (in mm) of the box. A boundary is still maintained around the box but the height depends on the number and size of variables displayed.

Hide

When you select this option, the frame surrounding the spatial report is not displayed.

Type -

The form of the grouping of the spatial reports data is controlled by these options.

Box

A rectangular box will be drawn around the data with an attachment line drawn to the centre of the box.

Opaque

If this checkbox is not enabled the spatial reports will be transparent with the background and network able to be seen through the reports.

Bracket

A square bracket [or] will be drawn at the beginning or end of the group of spatial report data depending on the location of the data relative to the link. The attachment line will be drawn to the centre of the front or end of the bracket.

Attachment Line

Colour

These buttons allow you to change the colour of the line attaching node reports to nodes.

Line Type

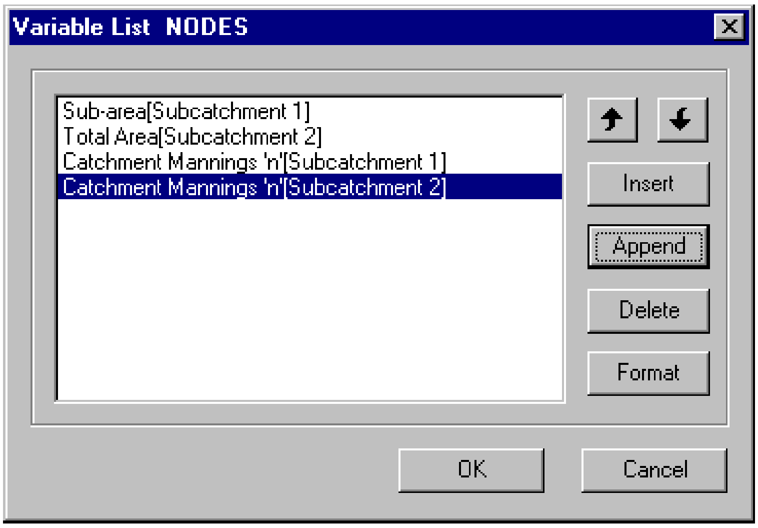
These buttons allow you to change the line type of the line attaching node reports to nodes.

Hide

When you select this option, the line from the Spatial Report to the node is not drawn.

Data Variables (Node)

This button loads the Data Variables dialog which allows you to select the data fields you wish to display in the Spatial Report for nodes. The list displayed in the following dialog contains the full names of all data items that will be included in your spatial report for nodes.



Insert/Append

Delete

Format

Delete

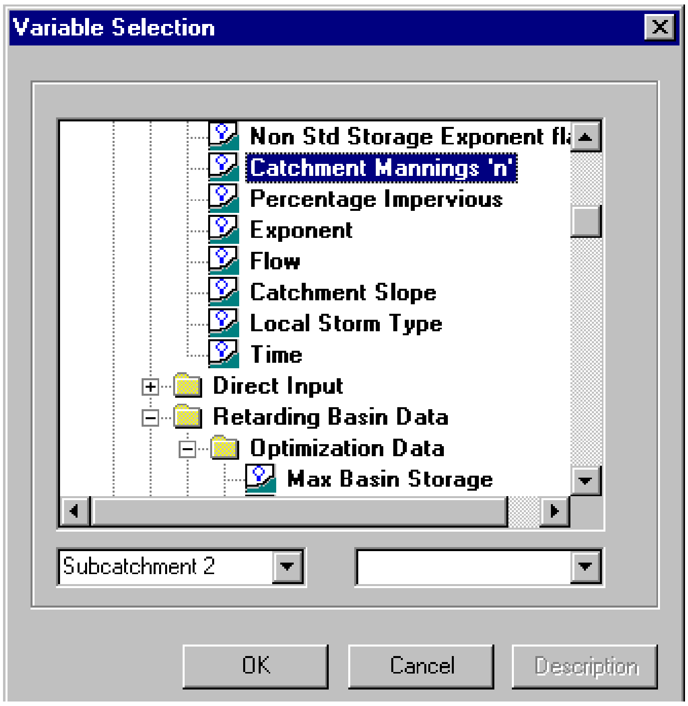
The delete button removes a report data variable from the list.

Insert/Append

These buttons allow you to insert a report data variable before the highlighted field in the list or at the end of the list respectively.

When you select either of these buttons the following dialog showing all available data is displayed. When OK is selected the highlighted field is added to the list shown in the preceding (parent) dialog.

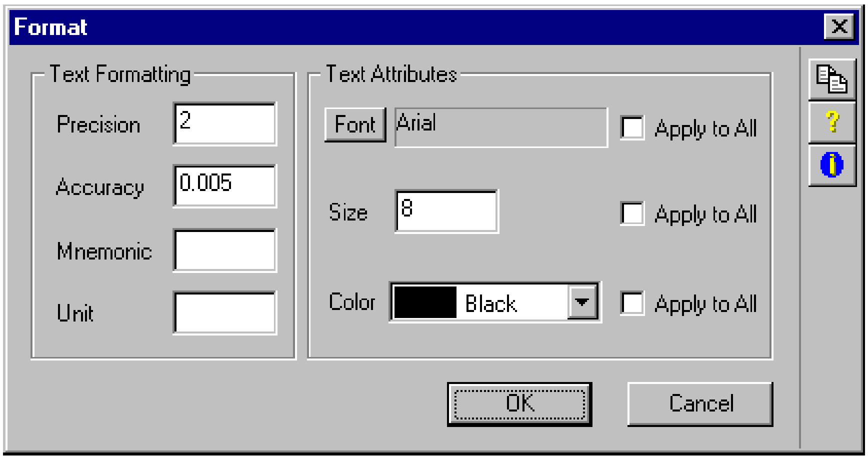
If the variable selected has multiple instances (ie. Conduits, Pumps, etc.) then a combination of Variable and Instance must be selected. To show all instances of a selected variable all combinations of Variable: Instance must be selected.



Format

This button takes you to a format dialog which allows you to select the format of the highlighted variable (the format specification is always attached to the data variable, even when that variable is removed from the list).

The description of the variable to be formatted is shown in the title bar of the dialog.



Text Formatting

Text Attributes

Text Formatting

Precision

This value specifies the number of places after the decimal point to display on the Spatial Report.

Accuracy

This value specifies the tolerance of the displayed data.

Mnemonic

This allows you to add a mnemonic to the start of each line of data displayed in the Spatial Reports.

Unit

This allows you to add a unit to the end of each line of data displayed in the Spatial Reports.

Text Attributes

Font

This allows you to specify the font in which you wish to display the currently selected variable of the Spatial Report. The normal Windows conventions regarding bitmap and true type fonts are supported.

Apply to All

If this checkbox is enabled then this font style will be applied to all the spatial report data for nodes.

Size

The height of the text (in mm) in the report line is entered here.

Apply to All

If this checkbox is enabled then this font size will be applied to all the spatial report data for nodes.

Text Colour

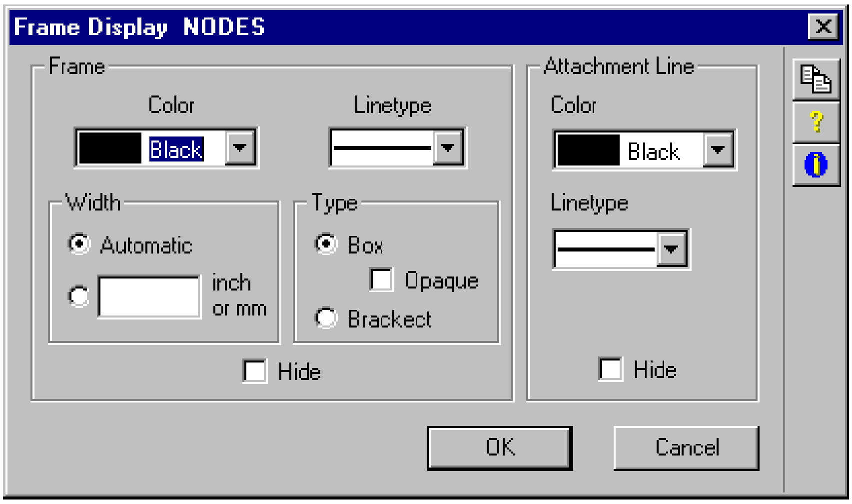
These buttons allow you to set the colour of the report text.

Apply to All

If this checkbox is enabled then this font colour will be applied to all the spatial report data for nodes.

Frame Display (Nodes)

This button loads the attributes dialog and allows you to specify such things as box colour and attachment line colour for Spatial Reports for Nodes. The type of frame used by the link data and the form of the attachment line may be modified from within the following dialog.



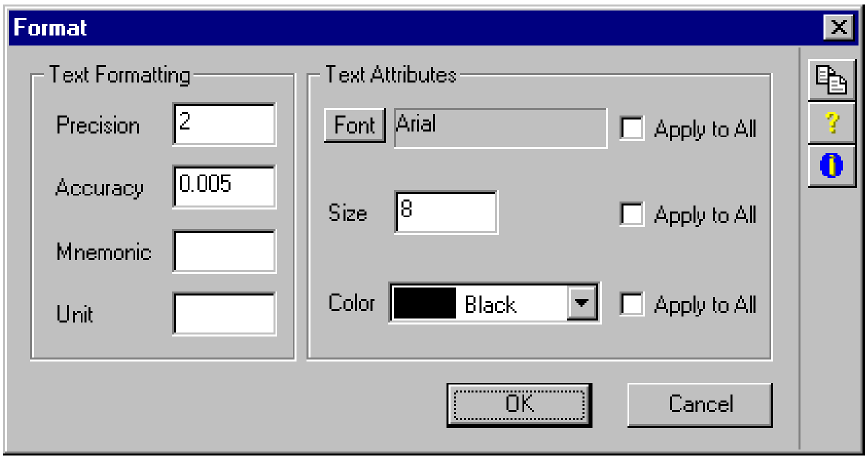
Frame

Attachment Line -

Format

This button takes you to a format dialog that allows you to select the format of the highlighted variable (the format specification is always attached to the data variable, even when that variable is removed from the list).

The description of the variable to be formatted is shown in the title bar of the dialog.



Text Formatting

Text Attributes

Attachment Line

Colour

These buttons allow you to change the colour of the line attaching node reports to nodes.

Line Type

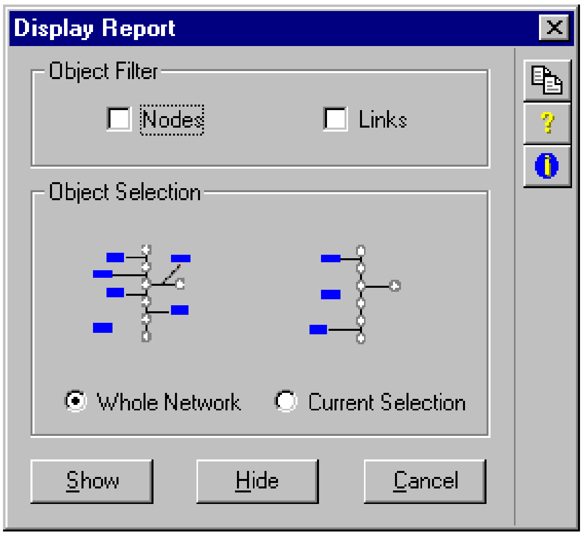
These buttons allow you to change the line type of the line attaching node reports to nodes.

Hide

When you select this option, the line from the Spatial Report to the node is not drawn.

Display Report

This command controls the hidden or shown status of Spatial Reports, in much the same way as other network objects are controlled. The command allows the Hiding or Showing of any selection of nodes/links in the network.



Hide

Show

Object Filter -

Object Selection -

Hide

This button causes all selected Reports to be hidden.

Show

This button causes all selected Reports to be shown (made visible).

Object Filter

Nodes, Links or both may be included in the spatial reports. At least one of these object types must be enabled for spatial reports to be displayed.

Nodes

This flags causes node objects to be included in the selection for Spatial Report.

Links

This flags causes link objects to be included in the selection for Spatial Report.

Object Selection

All Objects -

All objects (links and nodes) in the network will be exported.

Selection Only -

Only the objects (links and nodes) in the currently highlighted selection will be exported.

Encode

Encode causes the network to be redrawn with the currently selected "Graphical Encoding" Attributes. A "G" will be displayed in the status bar area of the network window (to the left of the bottom scroll bar) indicating the current view in which the network is drawn includes graphically encoded attributes.

Restore

This button will remove the graphical encoding attributes from the network window.

Load

This button allows you to load a pre-defined (saved) set of graphical encoding attributes.

Save

This button allows you to save the current attributes for re-use in this or other projects.

Cancel

This button cancels any changes to this dialog and restores the previous network view.

Preferences

Hide Arrows

This check box causes the network to be redrawn with arrowheads suppressed.

Fill Nodes

This check box causes the network to be shown with nodes filled with a solid fill pattern of the selected Node Color.

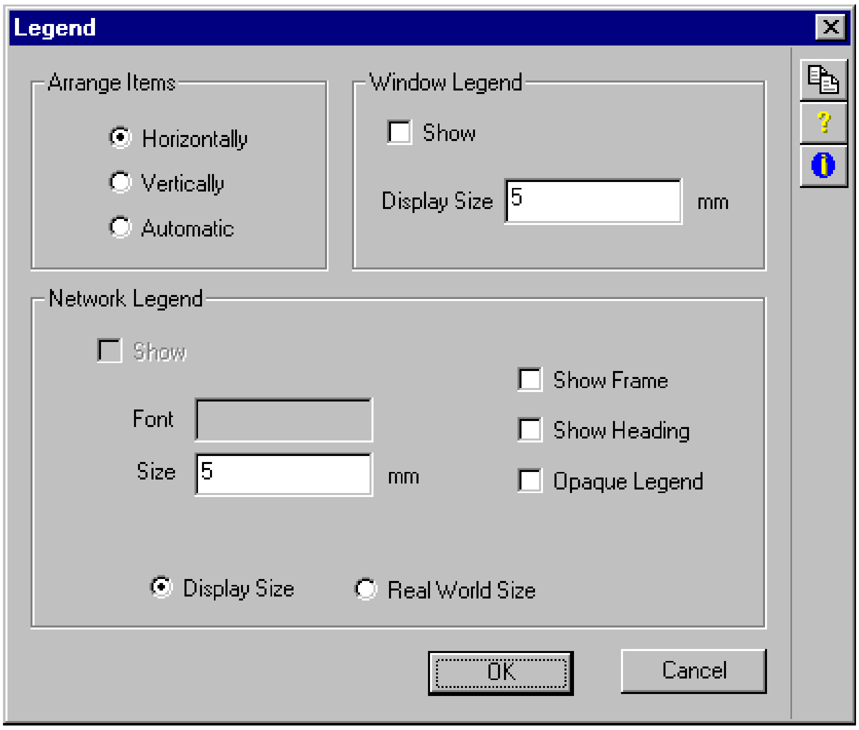
Hide Link Labels

This check box causes the link labels not to be shown.

Legend

Legend

This check box allows a legend showing the graphical attributes to be shown on the network.



Arrange Items

Window Legend

Network Legend

Arrange Items

The visual entities making up the graphical encoding may be arranged horizontally (in a single row), Vertically (in a single column) or Automatically (in a table depending on width and height requirements of each entity), depending on which radio button is selected.

Window Legend

The window legend is shown in a fixed location on the screen independent of panning or zooming.

Show -

When enabled a non-printable legend is shown on the screen.

Display Size -

The text in the window legend will be shown at the size (in mm or inches) entered in this field.

Network Legend

The network legend is shown in a fixed location on the network, regardless of the current window view. This legend is printed and plotted in the same manner as the network.

Font -

This allows you to specify the font in which you wish to display the window legend. The normal Windows conventions regarding bitmap and true type fonts are supported.

Size -

Display - When selected the size of the text is in inches (mm) regardless of scale.

Real World - When selected the text size is displayed relative to the network scale.

Show Frame -

When selected a rectangular frame is drawn around the legend.

Show Heading -

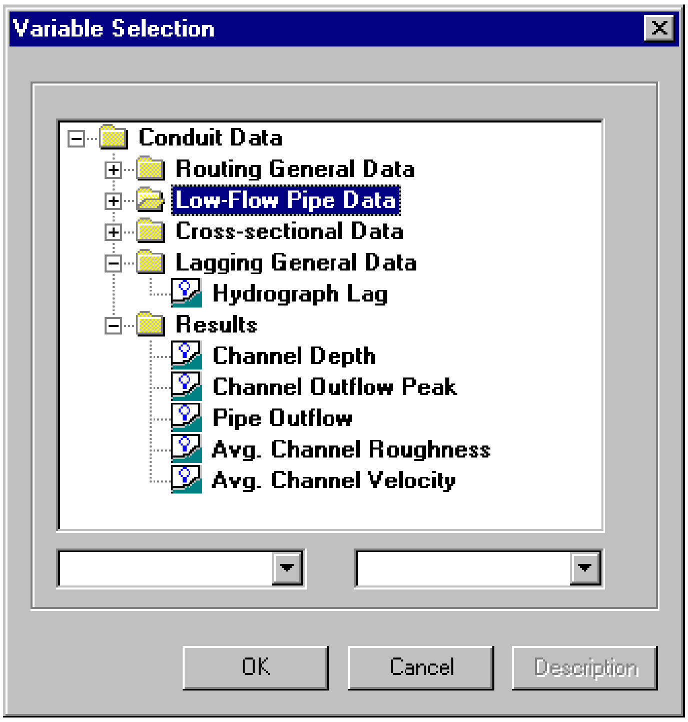
If this option is selected the legend title is shown.

Opaque Legend -

If this option is selected a legend title will be shown.

Variable

The variable list displayed when one of these buttons is selected shows the data and results that are available for graphical encoding. If the variable selected has multiple instances (ie. Residential, Commercial, etc.) then a combination of Variable and Instances must be selected. To show all instances of a selected variable all combinations of Variable: Instance must be selected.



Visual Entity

Three graphical entities, colour, size and text height, are available for each of the two object types.

Node Color

Node Size

Node Label Size

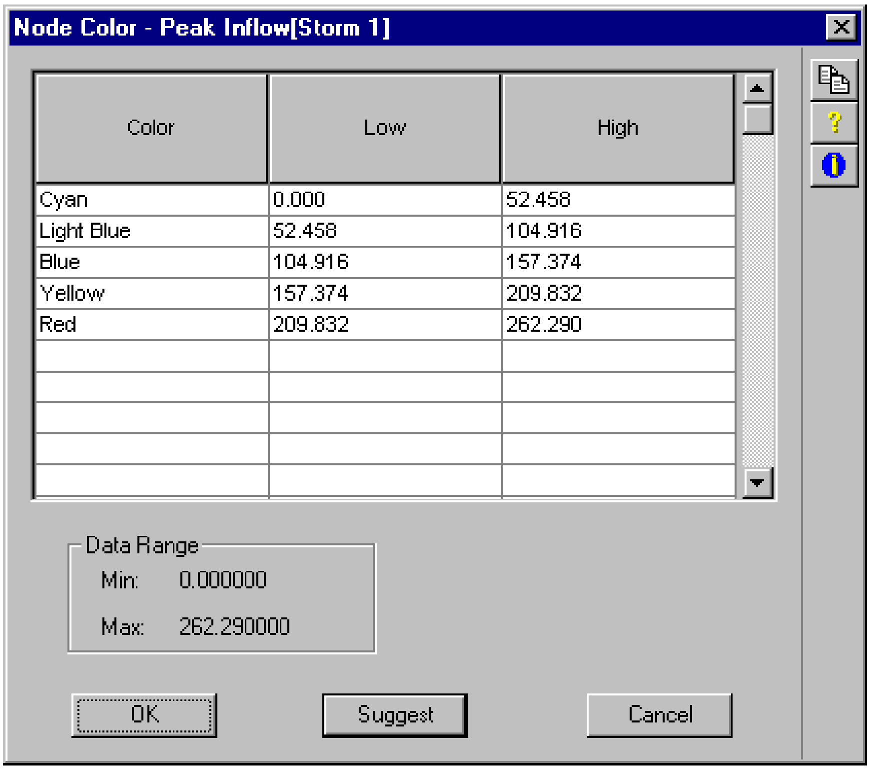
Link Color

Link Width

Link Label Size

Node Colour

Node colour is defined in ranges using an open-ended dialog list (DLIST). A colour is selected by clicking in the appropriate field and selecting a colour from the dialog that appears. The list follows the standard rules for a DLIST.



You can insert and delete rows using the Insert and Delete keys and you can scroll through the list using the arrow keys. Any number of rows can be included in the list but only 16 colours are supported.

The data is presented in discrete stepped ranges. Data is plotted in a selected colour provided it falls within the range: Low Value < Data Value <= High Value.

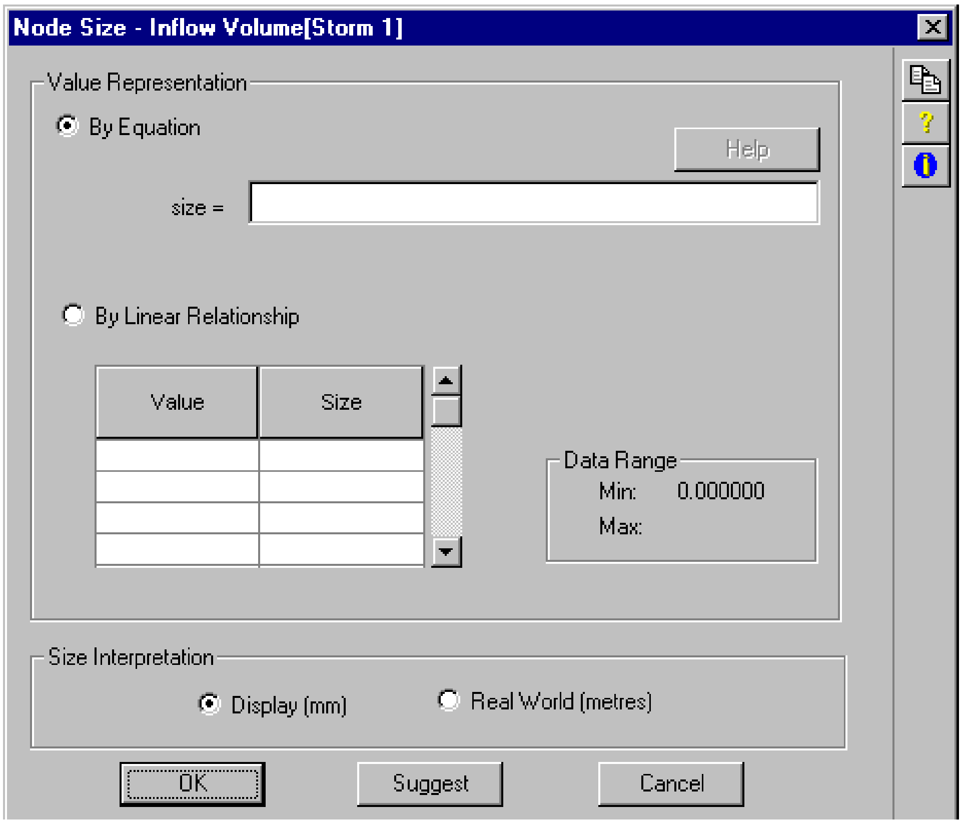
The Data Range shown in this dialog shows the maximum and minimum value of the selected variable currently contained within all objects in the database.

Suggest -

The Suggest button will break the minimum and maximum data range into 5 equal partitions and allocate a pre-determined colour to each.

Node Size

The node size can be used to represent the value of the data variable in one of two ways, either by an equation or by a stepwise linear function.



By Equation -

By Linear Relationship -

  Graph -

Size Interpretation -

Suggest -

By Equation

If this option is selected the text size is defined in terms of X, where X is the variable being shown. In its simplest form the equation is size = X, however arbitrary expressions can also be built with the syntax described here. Terms in the expression can consist of:

- numeric constants
- variable names
- arithmetic operators
- pre-defined functions

The following binary arithmetic operators are supported:

+	:	addition
-	:	subtraction
*	:	multiplication
/	:	division
%	:	remainder
^	:	exponentiation (raise to power)

Variables and numeric values can be used and parentheses () can also be used to any level of nesting. Expressions can be sequenced and separated by semicolons, with intermediate variables used. Variable names are alphanumeric strings and are not case-sensitive. White space (blank, tab, new line, etc) has no significance.

The following pre-defined functions are supported. These words are reserved and cannot be used as variable names:

abs(n)	-	absolute value of n
acos(x)	-	arc cosine of x, in radians
asin(x)	-	arc sine of x, in radian
atan(x)	-	arc tangent of x, in radians
ceil(x)	-	smallest integer >= x
cos(x)	-	cosine of x (x in radians)
cosh(x)	-	hyperbolic cosine of x (x in radians)
E10(x)	-	10 raised to the power x
exp(x)	-	exponential function of x
floor(x)	-	largest integer <= x
log10(x)	-	base-10 logarithm of x
log(x)	-	natural logarithm of x
sin(x)	-	sine of x (x in radians)
sinh(x)	-	hyperbolic sine of x
sqrt(x)	-	square root of x
tan(h)	-	tangent of x (x in radians)
tanh(h)	-	hyperbolic tangent of x (x in radians)
j0(x)	-	bessel function of first kind, order 0
j1(x)	-	bessel function of first kind, order 1
y0(x)	-	bessel function of second kind, order 0
y1(x)	-	bessel function of second kind, order 1
max(x1,x2)	-	larger of x1 and x2
min(x1,x2)	-	smaller of x1 and x2

Function arguments must be enclosed in parentheses.

e.g. sin(y), not siny or sin y.

The function names are not case-sensitive. There are no user-defined functions as yet.

Examples: 2.5*a^2/b + 1.2*c^2/sin(d)

By Linear Relationship

The text size will be displayed in a stepwise linear function using the Data Value/Node Size relationship entered in the following DLIST.

You can insert and delete rows using the Insert and Delete keys and you can scroll through the list using the arrow keys.

The data is presented in discrete stepped ranges. Data is plotted in a selected colour provided it falls within the range: Low Value < Data Value ≤ High Value.

The Data Range shown in this dialog shows the maximum and minimum value of the selected variable currently contained within all objects in the database.

Size

Display -

If this option is selected the size of the text will be in mm regardless of scale.

Real World -

If this option is selected the text size will be displayed relative to the network scale.

Suggest

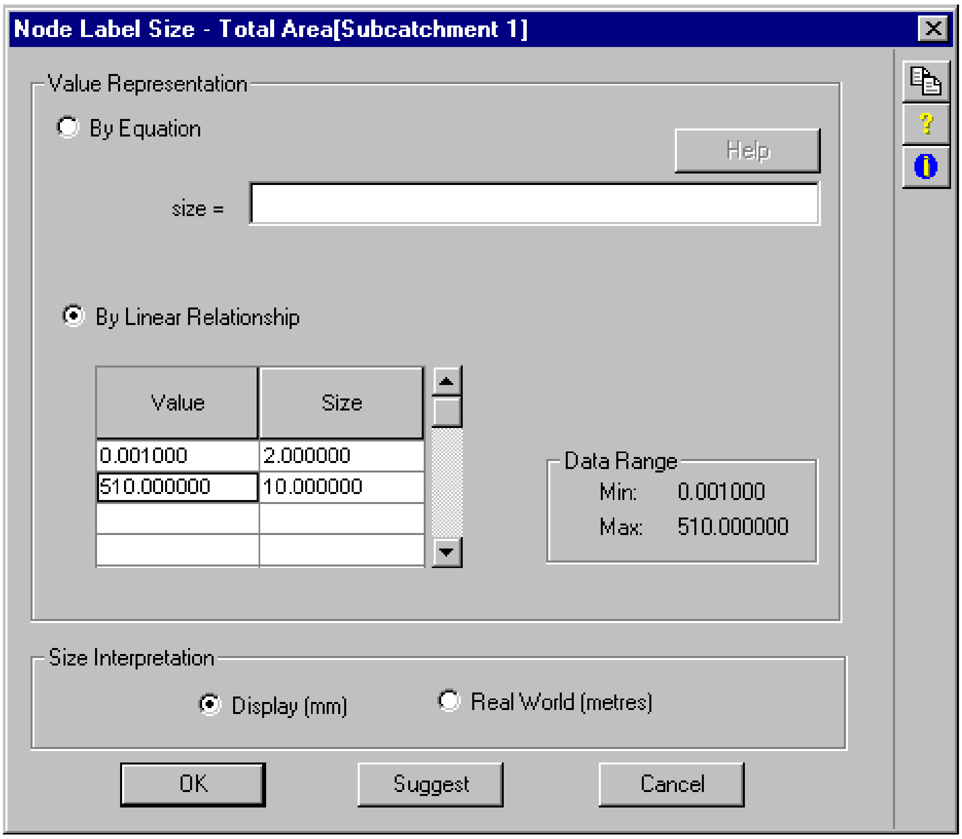
The Suggest button will break the minimum and maximum data range into either a linear relationship or a linear equation depending on the option selected.

Graph

The graph button will display the data entered in the value/size DLIST as an XY graph.

Node Label Size

The size of the text used for the node name can be used to represent the value of the data variable in one of two ways, either by an equation or by a stepwise linear function.



By Equation -

By Linear Relationship -

Graph -

Size Interpretation -

Suggest -

By Equation

If this option is selected the text size is defined in terms of X, where X is the variable being shown. In its simplest form the equation is size = X, however arbitrary expressions can also be built with the syntax described here. Terms in the expression can consist of:

- numeric constants
- variable names

- arithmetic operators
- pre-defined functions

The following binary arithmetic operators are supported:

+	:	addition
-	:	subtraction
*	:	multiplication
/	:	division
%	:	remainder
^	:	exponentiation (raise to power)

Variables and numeric values can be used and parentheses () can also be used to any level of nesting. Expressions can be sequenced and separated by semicolons, with intermediate variables used. Variable names are alphanumeric strings and are not case-sensitive. White space (blank, tab, new line, etc) has no significance.

The following pre-defined functions are supported. These words are reserved and cannot be used as variable names:

abs(n)	-	absolute value of n
acos(x)	-	arc cosine of x, in radians
asin(x)	-	arc sine of x, in radian
atan(x)	-	arc tangent of x, in radians
ceil(x)	-	smallest integer >= x
cos(x)	-	cosine of x (x in radians)
cosh(x)	-	hyperbolic cosine of x (x in radians)
E10(x)	-	10 raised to the power x
exp(x)	-	exponential function of x
floor(x)	-	largest integer <= x
log10(x)	-	base-10 logarithm of x
log(x)	-	natural logarithm of x
sin(x)	-	sine of x (x in radians)
sinh(x)	-	hyperbolic sine of x
sqrt(x)	-	square root of x
tan(h)	-	tangent of x (x in radians)
tanh(h)	-	hyperbolic tangent of x (x in radians)
j0(x)	-	bessel function of first kind, order 0
j1(x)	-	bessel function of first kind, order 1
y0(x)	-	bessel function of second kind, order 0
y1(x)	-	bessel function of second kind, order 1
max(x1,x2)	-	larger of x1 and x2
min(x1,x2)	-	smaller of x1 and x2

Function arguments must be enclosed in parentheses.

e.g. sin(y), not siny or sin y.

The function names are not case-sensitive. There are no user-defined functions as yet.

Examples: 2.5*a^2/b + 1.2*c^2/sin(d)

By Linear Relationship

The text size will be displayed in a stepwise linear function using the Data Value/Node Size relationship entered in the following DLIST.

You can insert and delete rows using the Insert and Delete keys and you can scroll through the list using the arrow keys.

The data is presented in discrete stepped ranges. Data is plotted in a selected colour provided it falls within the range: Low Value < Data Value ≤ High Value.

The Data Range shown in this dialog shows the maximum and minimum value of the selected variable currently contained within all objects in the database.

Size

Display -

When selected the size of the text is in inches (or mm) regardless of scale.

Real World -

When selected the text size is displayed relative to the network scale.

Suggest

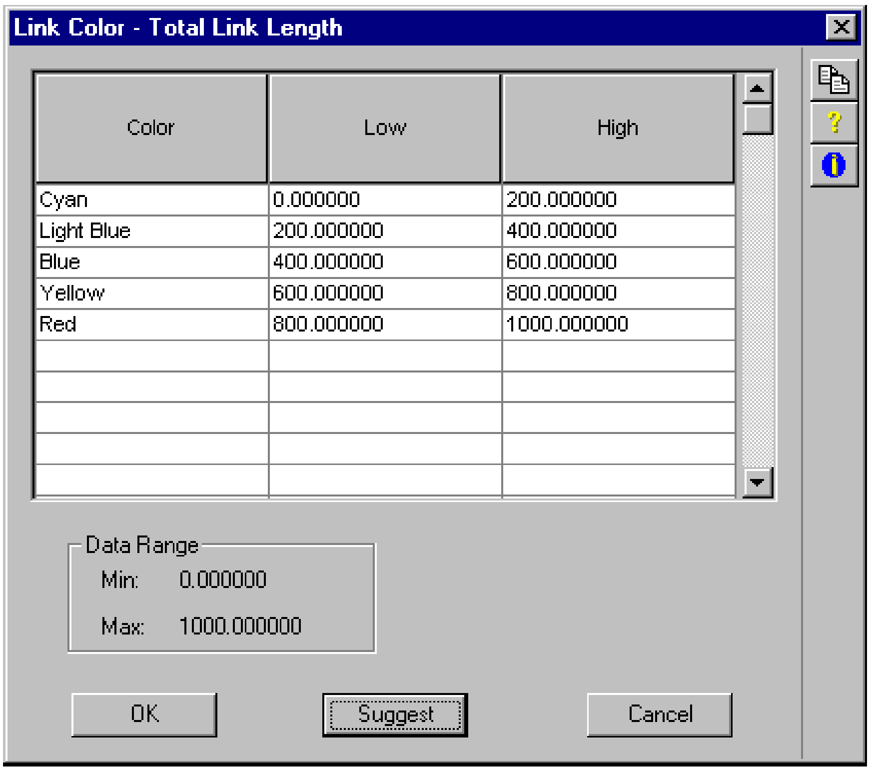
The Suggest button will break the minimum and maximum data range into either a linear relationship or a linear equation depending on the option selected.

Graph

The graph button will display the data entered as an XY graph.

Link Colour

Link colour is defined in ranges using an open-ended dialog list (DLIST). A colour is selected by clicking in the appropriate field and selecting a colour from the dialog that appears. The list follows the standard rules for a DLIST. You can insert and delete rows using the Insert and Delete keys and you can scroll through the list using the arrow keys. Any number of rows can be included in the list but only 16 colours are supported.



The data is presented in discrete stepped ranges. Data is plotted in a selected colour provided it falls within the range: Low Value < Data Value ≤ High Value.

The Data Range shown in this dialog shows the maximum and minimum value of the selected variable currently contained within all objects in the database.

Suggest -

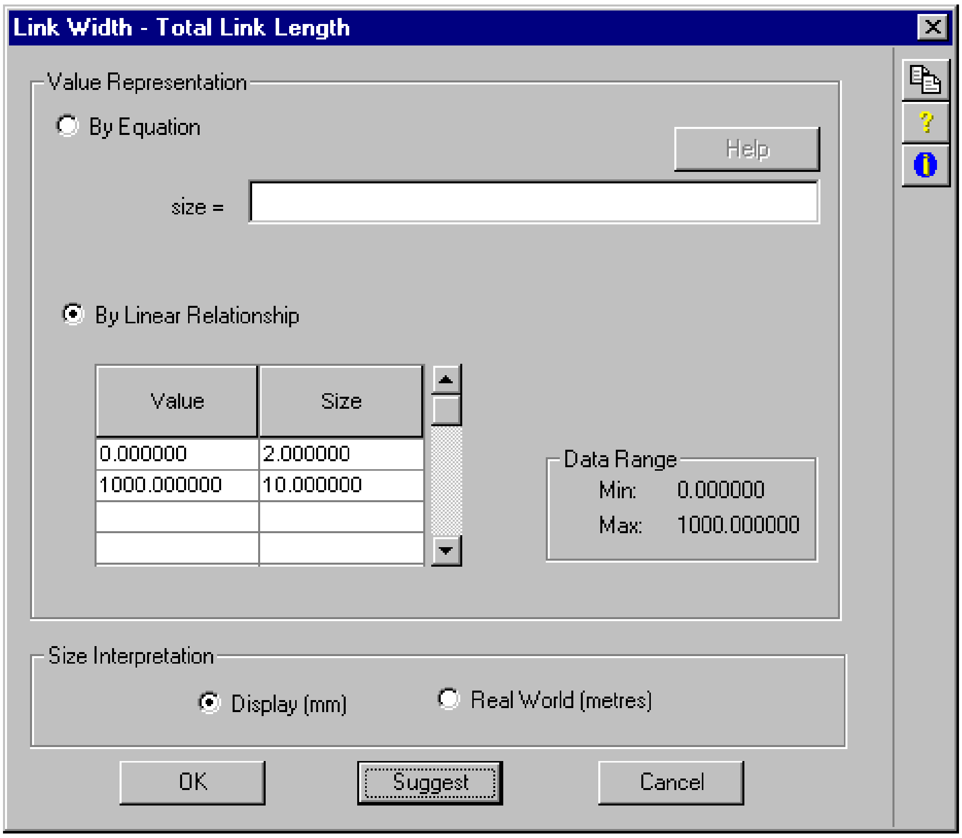
The Suggest button will break the minimum and maximum data range into 5 equal partitions and allocate a pre-determined colour to each.

Graph

The graph button will display the data entered in the value/size DLIST as an XY graph.

Link Width

The Link width can be used to represent the value of the data variable in one of two ways, either by an equation or by a stepwise linear function.



By Equation -

By Linear Relationship -

Graph

Size Interpretation -

Suggest -

By Equation

If this option is selected the link width is defined in terms of X, where X is the variable being shown. In its simplest form the equation is size = X, however arbitrary expressions can also be built with the syntax described here. Terms in the expression can consist of:

- numeric constants
- variable names

- arithmetic operators
- pre-defined functions

The following binary arithmetic operators are supported:

+ : addition

- : subtraction

* : multiplication

/ : division

% : remainder

^ : exponentiation (raise to power)

Variables and numeric values can be used and parentheses () can also be used to any level of nesting. Expressions can be sequenced and separated by semicolons, with intermediate variables used. Variable names are alphanumeric strings and are not case-sensitive. White space (blank, tab, new line, etc) has no significance.

The following pre-defined functions are supported. These words are reserved and cannot be used as variable names:

abs(n)	-	absolute value of n
acos(x)	-	arc cosine of x, in radians
asin(x)	-	arc sine of x, in radian
atan(x)	-	arc tangent of x, in radians
ceil(x)	-	smallest integer >= x
cos(x)	-	cosine of x (x in radians)
cosh(x)	-	hyperbolic cosine of x (x in radians)
E10(x)	-	10 raised to the power x
exp(x)	-	exponential function of x
floor(x)	-	largest integer <= x
log10(x)	-	base-10 logarithm of x
log(x)	-	natural logarithm of x
sin(x)	-	sine of x (x in radians)
sinh(x)	-	hyperbolic sine of x
sqrt(x)	-	square root of x
tan(h)	-	tangent of x (x in radians)
tanh(h)	-	hyperbolic tangent of x (x in radians)
j0(x)	-	bessel function of first kind, order 0
j1(x)	-	bessel function of first kind, order 1
y0(x)	-	bessel function of second kind, order 0
y1(x)	-	bessel function of second kind, order 1
max(x1,x2)	-	larger of x1 and x2
min(x1,x2)	-	smaller of x1 and x2

Function arguments must be enclosed in parentheses.

e.g. sin(y), not siny or sin y.

The function names are not case-sensitive. There are no user-defined functions as yet.

Examples: 2.5*a^2/b + 1.2*c^2/sin(d)

By Linear Relationship

The link width will be displayed in a stepwise linear function using the Data Value/Node Size relationship entered in the following DLIST.

You can insert and delete rows using the Insert and Delete keys and you can scroll through the list using the arrow keys.

The data is presented in discrete stepped ranges. Data is plotted in a selected colour provided it falls within the range: Low Value < Data Value ≤ High Value.

The Data Range shown in this dialog shows the maximum and minimum value of the selected variable currently contained within all objects in the database.

Size

Display -

When selected the width of the link is in inches (or mm) regardless of scale.

Real World -

If this option is selected the link width will be displayed relative to the network scale.

Suggest

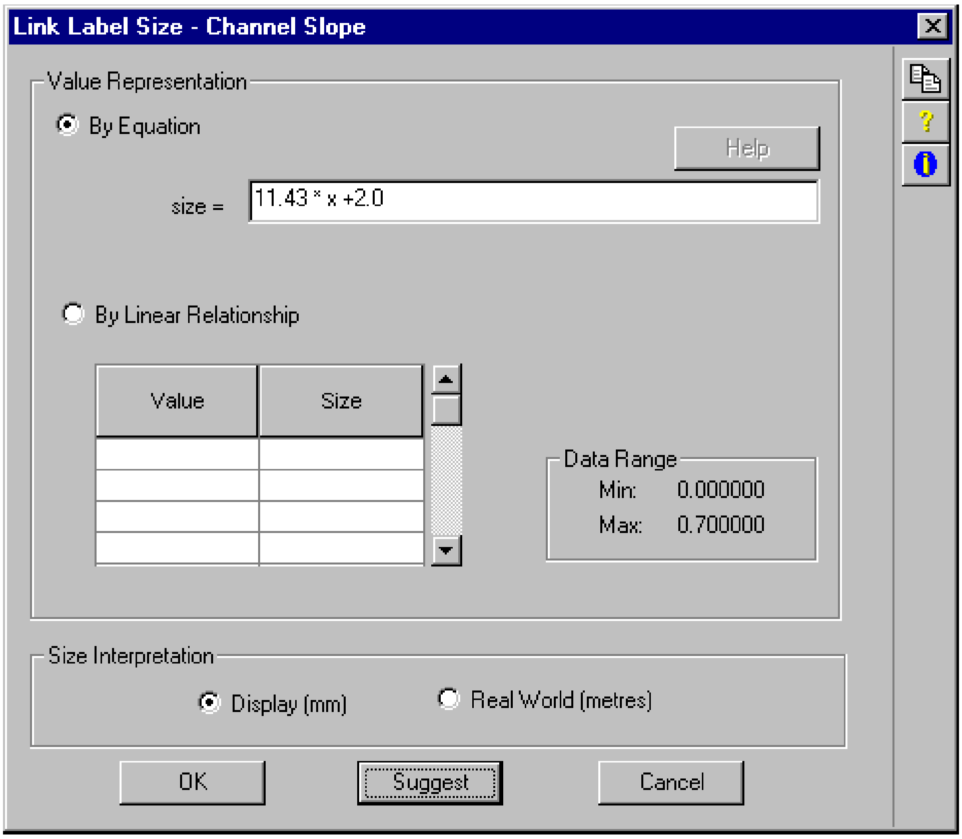
The Suggest button will break the minimum and maximum data range into either a linear relationship or a linear equation depending on the option selected.

Graph

The graph button will display the data entered in the value/size DLIST as a XY graph.

Link Label Size

The size of the text used for the link name can be used to represent the value of the data variable in one of two ways, either by an equation or by a stepwise linear function.



By Equation -

By Linear Relationship -

Graph -

Size -

Suggest -

By Equation

If this option is selected the text size is defined in terms of X, where X is the variable being shown. In its simplest form the equation is size = X, however arbitrary expressions can also be built with the syntax described here. Terms in the expression can consist of:

- numeric constants
- variable names
- arithmetic operators
- pre-defined functions

The following binary arithmetic operators are supported:

+	:	addition
-	:	subtraction
*	:	multiplication
/	:	division
%	:	remainder
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Variables and numeric values can be used and parentheses () can also be used to any level of nesting. Expressions can be sequenced and separated by semicolons, with intermediate variables used. Variable names are alphanumeric strings and are not case-sensitive. White space (blank, tab, new line, etc) has no significance.

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E10(x)	-	10 raised to the power x
exp(x)	-	exponential function of x
floor(x)	-	largest integer <= x
log10(x)	-	base-10 logarithm of x
log(x)	-	natural logarithm of x
sin(x)	-	sine of x (x in radians)
sinh(x)	-	hyperbolic sine of x
sqrt(x)	-	square root of x
tan(h)	-	tangent of x (x in radians)
tanh(h)	-	hyperbolic tangent of x (x in radians)
j0(x)	-	bessel function of first kind, order 0
j1(x)	-	bessel function of first kind, order 1
y0(x)	-	bessel function of second kind, order 0
y1(x)	-	bessel function of second kind, order 1
max(x1,x2)	-	larger of x1 and x2

min(x1,x2) - smaller of x1 and x2

Function arguments must be enclosed in parentheses.

e.g. sin(y), not siny or sin y.

The function names are not case-sensitive. There are no user-defined functions as yet.

Examples: 2.5*a^2/b + 1.2*c^2/sin(d)

By Linear Relationship

The node size will be displayed in a stepwise linear function using the Data Value/Node Size relationship entered in the following DLIST.

You can insert and delete rows using the Insert and Delete keys and you can scroll through the list using the arrow keys.

The data is presented in discrete stepped ranges. Data is plotted in a selected colour provided it falls within the range: Low Value < Data Value ≤ High Value.

The Data Range shown in this dialog shows the maximum and minimum value of the selected variable currently contained within all objects in the database.

Size

Display -

If this option is selected the size of the text will be in mm regardless of scale.

Real World -

If this option is selected the text size will be displayed relative to the network scale.

Suggest

The Suggest button will break the minimum and maximum data range into either a linear relationship or a linear equation depending on the option selected.

Graph

The graph button will display the data entered as an XY graph.

THE WINDOWS MENU

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File

THE FILE MENU

The "File" menu lists commands that relate to your entire database. You can create, open, merge and close a database. While working on a database, you can save your editing changes, return to the last saved version or exit the application.

A brief description of the available file menu commands is given below.

New

Open

Close

Save

Save As

Revert

Import Data

Import External Databases

Export Data

Print

Print Preview

Print Setup

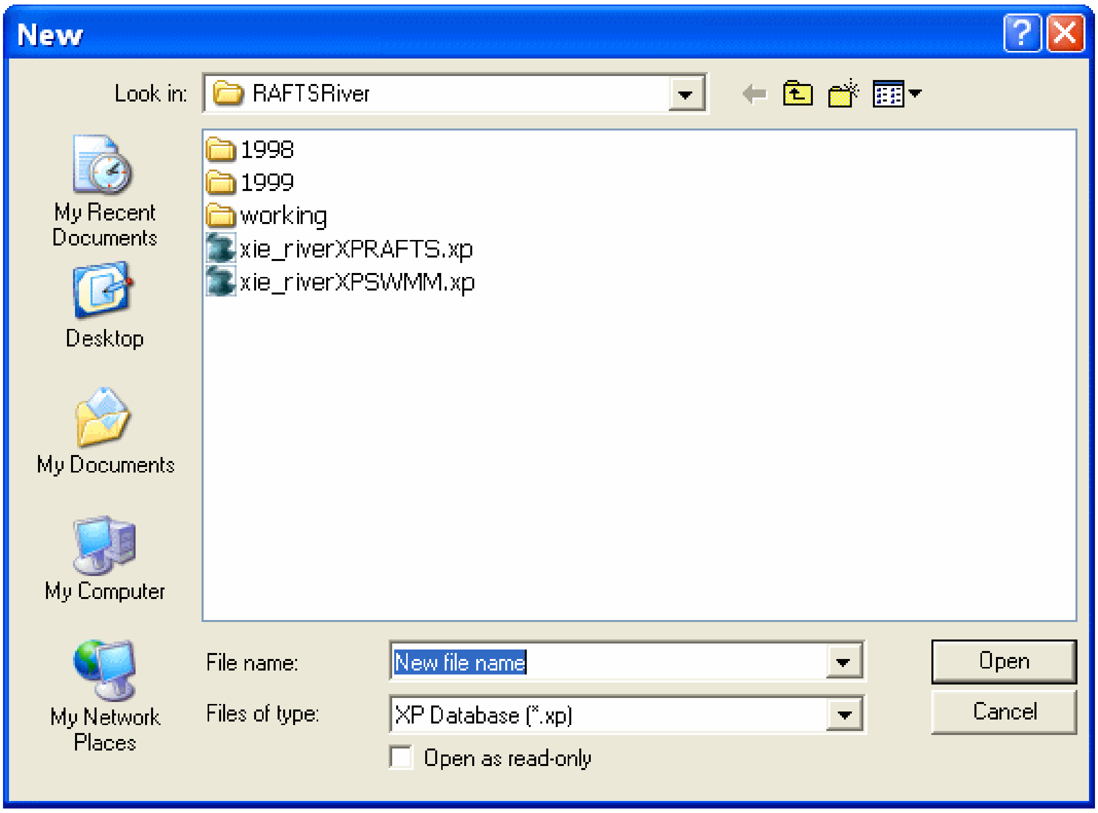
Recent Files

Exit

New

This menu command is used to create a new database. There are two options: Blank Job or Create From Template.

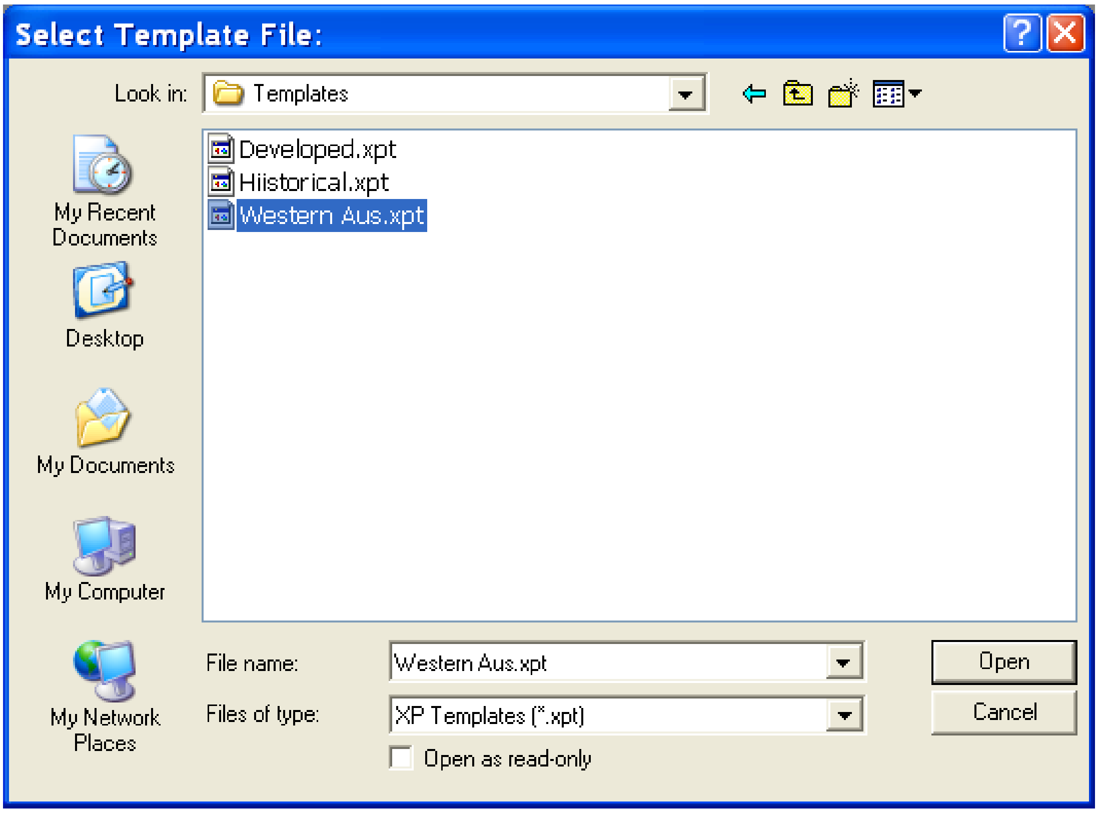
Upon selecting Blank Job, a dialog box requesting the name of the new database appears. If the name of an existing file is entered, confirmation to overwrite it is requested and, if granted, the existing file is destroyed.



The program then displays the name of the new empty database in the window title and proceeds to enable and disable appropriate menu commands. Only one database can be active at any one time. Although not mandatory it is good practice to give the new file a .XP extension. This makes retrieval of the file more straightforward when using the "Open" command.

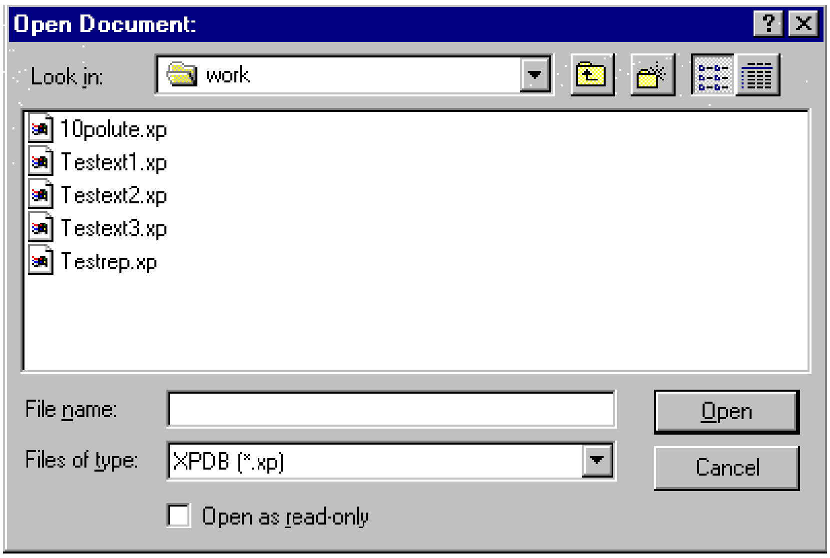
Every xprafts file is based on a template. A template determines the basic structure for a file and may contain settings such as, fonts, XP Table Settings, Spatial Report and Graphical Encoding settings, Job Control parameters, rainfall data and almost any other parameter used by xprafts.

Select the Create From Template option and after the New File is created, the flowing dialog appears.



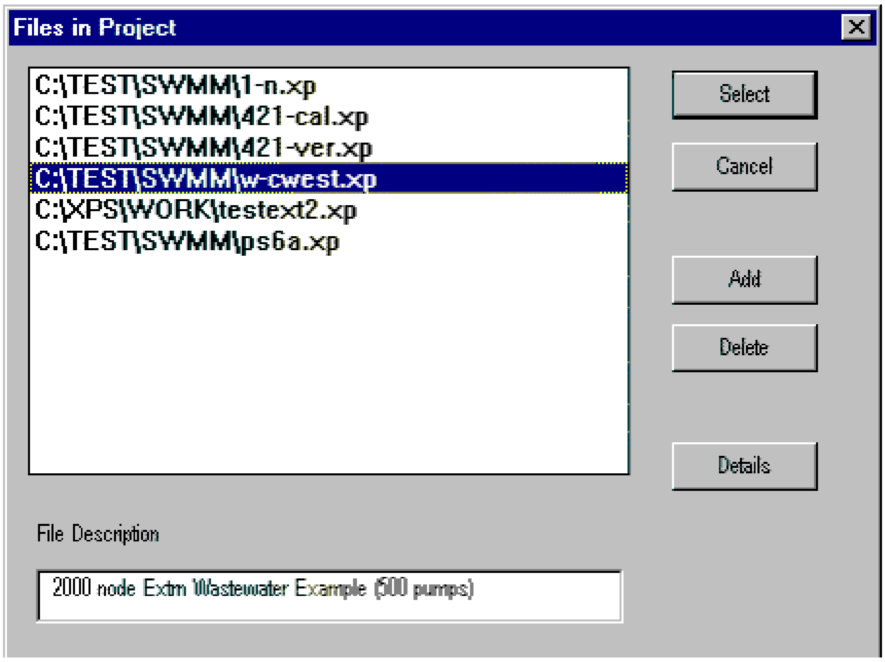
Navigate to the location of the template and click on Open.

Open



This command is used to open an existing database and make it active. When this option is selected the Get File dialog box below will be shown with a default mask "*.xp" To select a file, double-click on the name or type the complete name instead of the mask.

If the PROJECTS option is enabled the Get File dialog box will only display files that are part of the current project as shown below.



When a database is successfully opened, a backup file with the extension ".BAK" is created and appropriate menu commands are enabled and disabled. The backup is not updated until the database is closed and reopened. Only one database can be opened at any one time and its name is displayed in the window title.

Close

Choose this option if you are finished with this database and want to open another existing file or create a new one. If no changes have been made to the current file, it will be closed immediately, otherwise a "Save Changes?" prompt will appear, allowing you the option of closing without saving changes, or cancelling the "Close" operation. Unless merging files the active database must be closed before opening another one.

When the database is closed the temporary work file is copied to the original database. Until close is selected you may revert to your original unchanged database by selecting the "Revert" command from this menu.

A file may also be closed by clicking on the small rectangular "close box" in the left hand corner of the title bar.

Save

XP maintains an internal working copy of the database for editing sessions. Changes made while editing are not committed to the permanent database unless explicitly instructed by using the Save command. The Save command commits all changes made to the working database to the permanent database whose file name is the window title. The current view is also saved, so that when re-opened, the display will be in the same state as when the database was saved.

Save As Template

The easiest way to create a new job is from a Template. Select this command to save the current XP file as a Template. The new Template contain all of the parameter used by XP including settings such as, fonts, XP Table Settings, Spatial Report and Graphical Encoding settings, Job Control parameters, rainfall data.

When selected, this command will prompt for an XPT file name.

See Also New File From Template.

Save As

Copies of the working database (see Save command) can be saved under different names by issuing this command. A dialog box prompts for the new database name; the copy is then made and the new name becomes the current database.

The "Save As" and "Save" commands give you flexible control over the timing and permanence of data changes.

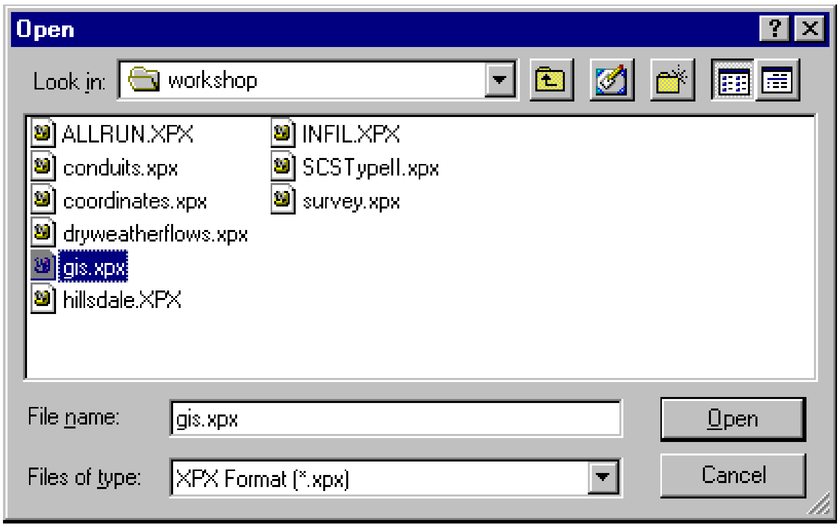
Revert

By choosing "Revert" the working database will revert to the last "Saved" version. There is an additional dialog asking confirmation of this action to ensure there is no unintentional change.

Import Data

Although every attempt has been made to implement the undocumented features implemented in a variety of customized programs, we offer no guarantee that data will be imported exactly as originally coded.

Import is offered as a tool to assist in creating your database. All imported data <u>MUST</u> be verified to ensure it is a true representation of the original information before any attempt is made to use the generated results.



XPX Format File

Import

Spreadsheet Import

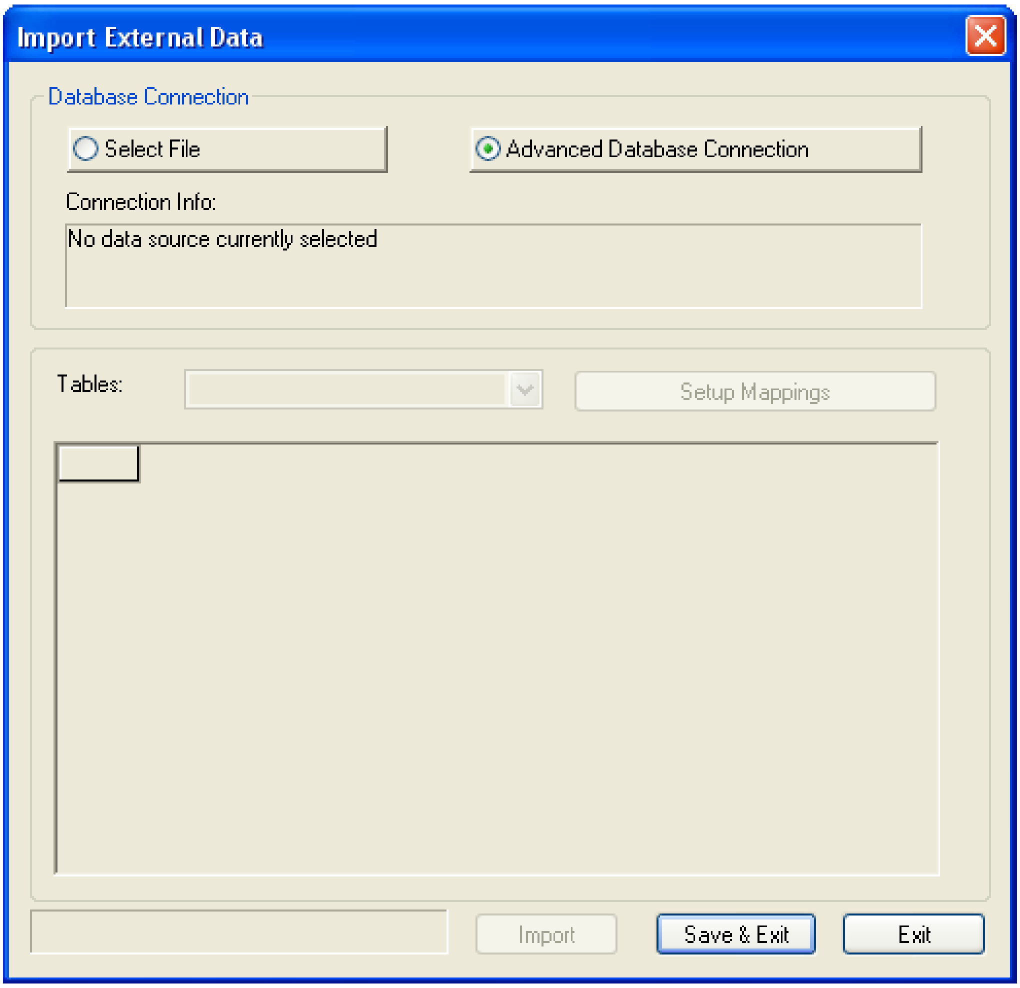
Spreadsheet information may be imported by adding the $TABLE keyword to the spreadsheet file, then creating a CSV (comma separated variable) file and importing this file using the XPX import feature.

The format comprizes a set of commands (keywords) followed by parameters. The commands allow the creation of objects (nodes,links), and assigning of data to these objects.

External data may be imported into all XP applications (e.g. XP-Rat2000, XP-AQUALM, XP-SWMM, XP-EXTRAN etc.) via the “Import Data...” command under the “Special” menu. The command prompts the user for a text filename with a suggested “.XPX” extension (to indicate an XP-Exchange format file). Once a file is selected, the data specifications in that file are imported into the XP network and database.

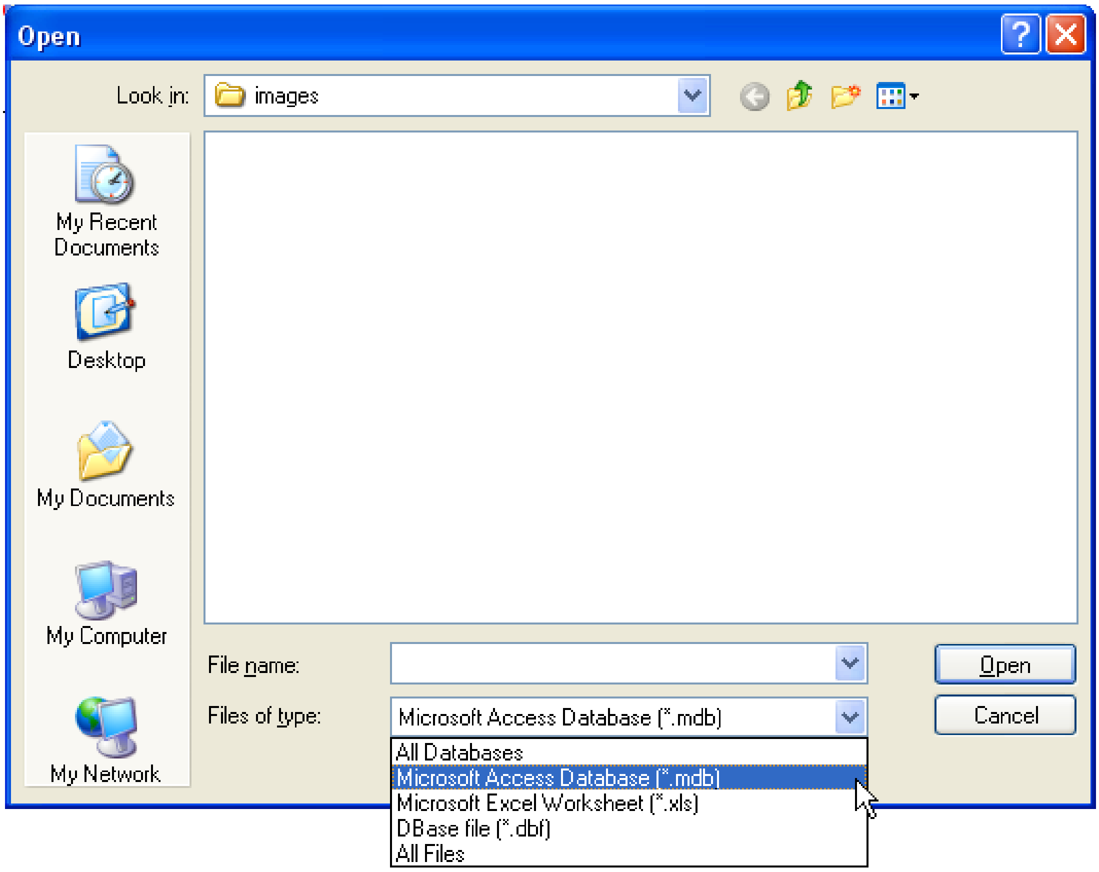
To obtain the “Field Name” and “Instance” for database fields, you need to use the “Get Field Info” facility in XP. To do this, the database field is first selected by holding down the <CTRL> key and clicking in the dialog item linked to it with the mouse (this is the same preamble as COPYing a data item prior to PASTEing). Then, press the <ALT> key and the <I> key simultaneously to “Get Info” on the selected data item. A dialog window pops up, displaying the info you need. You can get help on this dialog in the usual way by holding down the <ALT> key and clicking on the item of interest with the mouse.

Import External Databases

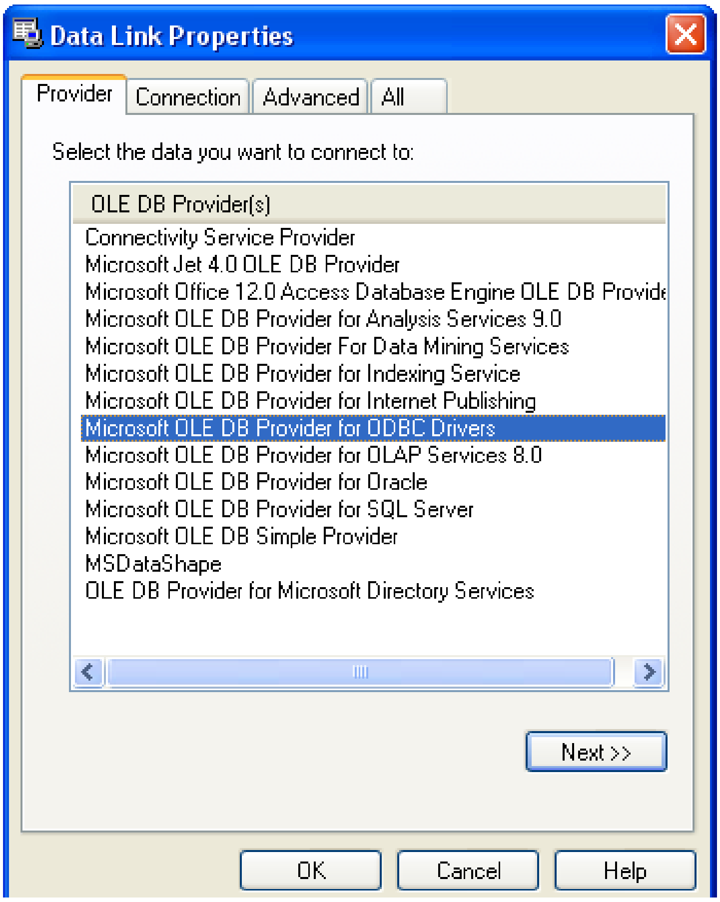


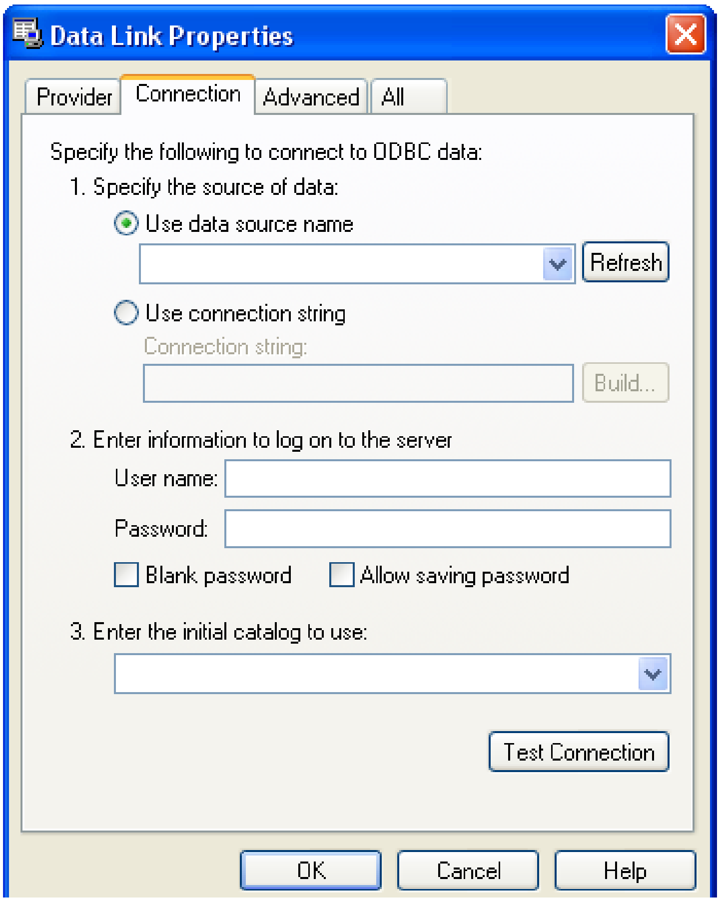
Database Connection:

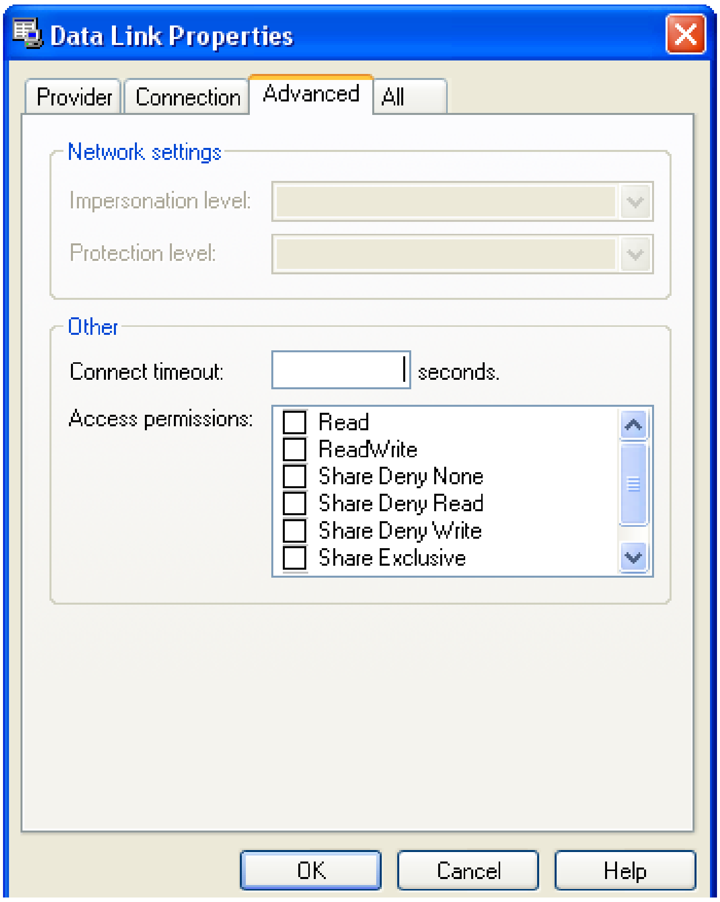
Select File:

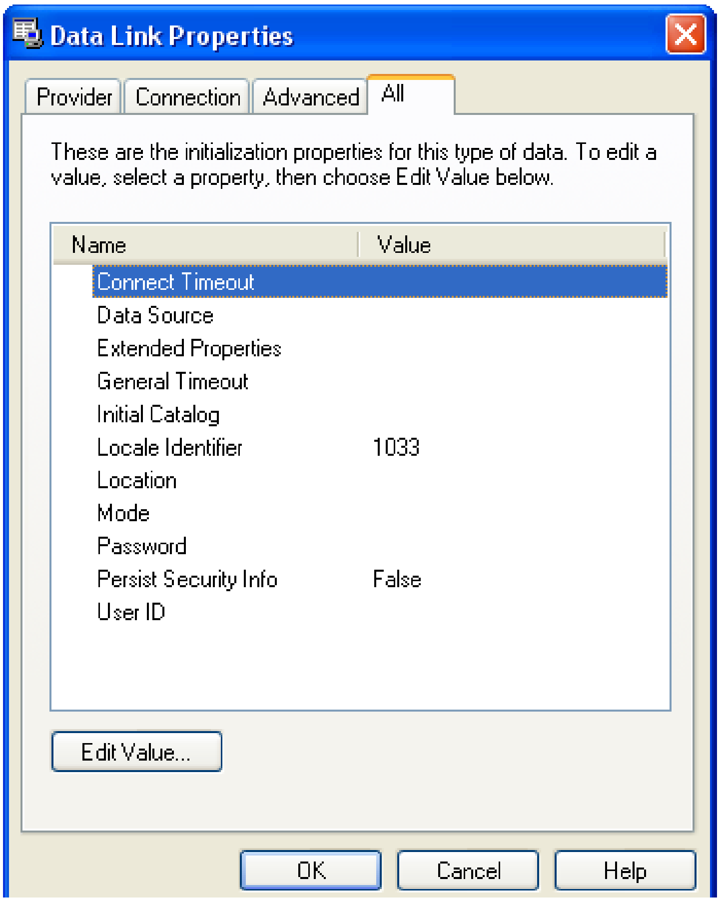


Advanced Database Connection:


Data Link Properties
Provider
Connection
Advanced
All
Select the data you want to connect to:
OLE DB Provider(s)
Connectivity Service Provider
Microsoft Jet 4.0 OLE DB Provider
Microsoft Office 12.0 Access Database Engine OLE DB Provide
Microsoft OLE DB Provider for Analysis Services 9.0
Microsoft OLE DB Provider For Data Mining Services
Microsoft OLE DB Provider for Indexing Service
Microsoft OLE DB Provider for Internet Publishing
Microsoft OLE DB Provider for ODBC Drivers
Microsoft OLE DB Provider for OLAP Services 8.0
Microsoft OLE DB Provider for Oracle
Microsoft OLE DB Provider for SQL Server
Microsoft OLE DB Simple Provider
MSDataShape
OLE DB Provider for Microsoft Directory Services
Next >>
OK
Cancel
Help

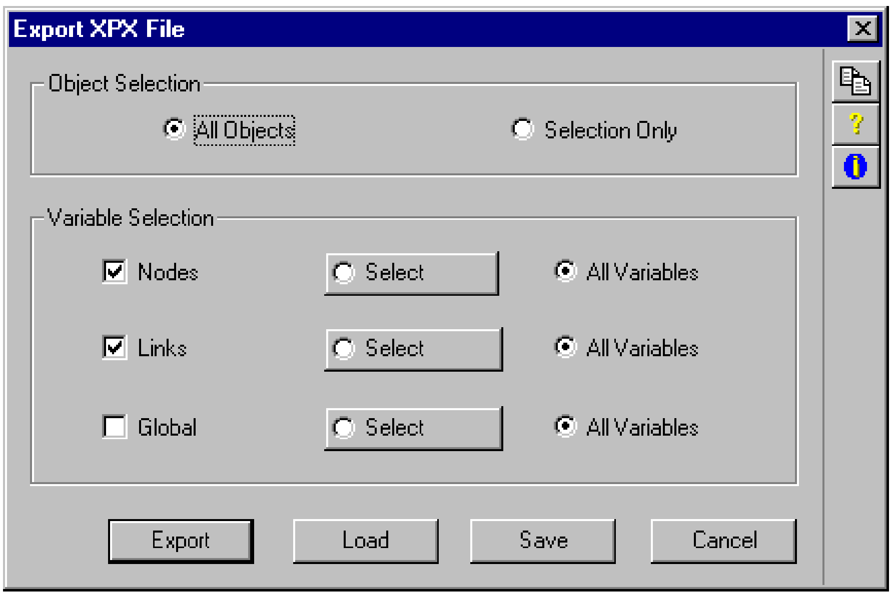

Data Link Properties
Provider
Connection
Advanced
All
Specify the following to connect to ODBC data:
1. Specify the source of data:
Use data source name
Refresh
Use connection string
Connection string:
Build...
2. Enter information to log on to the server
User name:
Password:
Blank password
Allow saving password
3. Enter the initial catalog to use:
Test Connection
OK
Cancel
Help


Data Link Properties
Provider
Connection
Advanced
All
Network settings
Impersonation level:
Protection level:
Other
Connect timeout:
seconds.
Access permissions:
Read
ReadWrite
Share Deny None
Share Deny Read
Share Deny Write
Share Exclusive
OK
Cancel
Help



Export Data

Data may be written to a text file in an XPX format using this option.



Object Selection

Variable Selection

Object Selection

All Objects -

All objects (links and nodes) in the network will be exported.

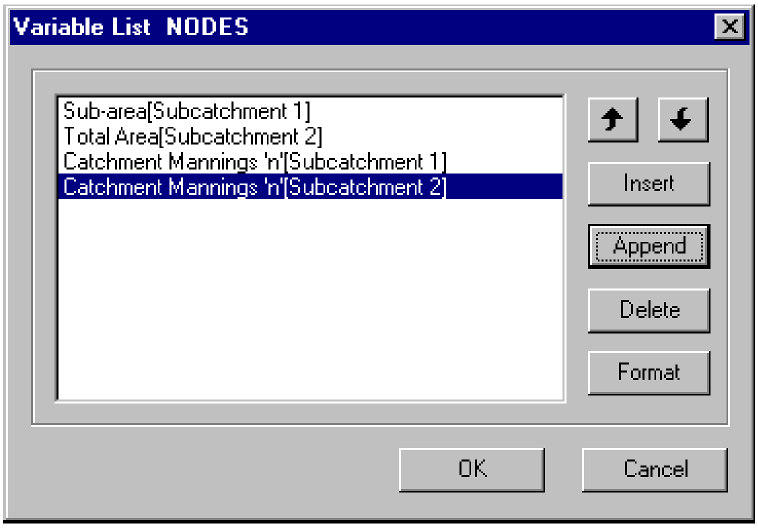
Selection Only -

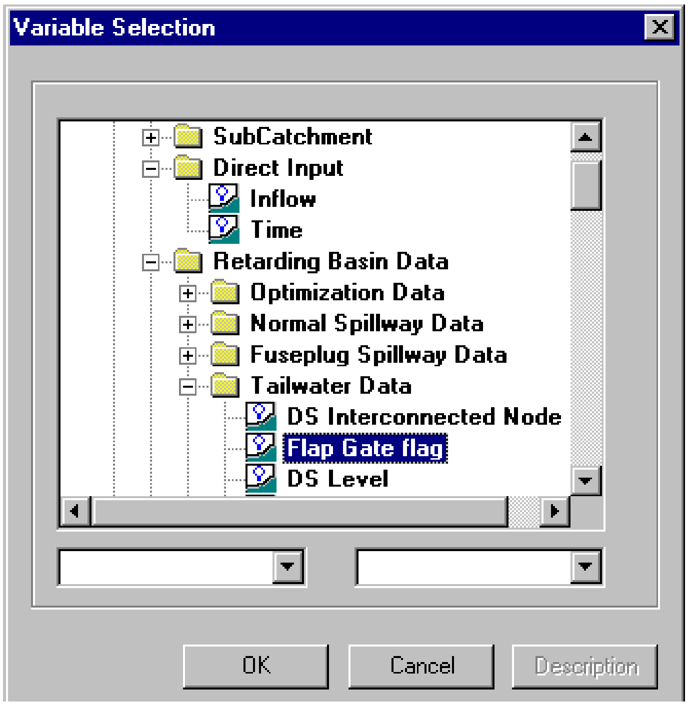
Only the objects (links and nodes) in the currently highlighted selection will be exported.

Variable Selection

Data variables may be exported for links and/or nodes. All variables may be exported or a subset may be chosen using the select button. Variables are added to the list using the same selection procedure as for Spatial Reports.

If the Select radio button is pressed you will be asked to enter the variable names you wish to export, otherwise All variables will be exported.





Print

Print the current view of the network.

Print Preview

Preview how the current view of the network will appear when printed.

Print Setup

Set the printer page size etc.

Exit

The "Exit" menu option ends the current session and returns to the operating system. XP will give you the option to save any opened database whose changes have not been saved, or to cancel the "Exit" command and remain in the XP environment.

Note that changes to the database are not restricted to just data. Any change in scale, location or highlighting of an object will also cause the "Save Changes?" dialog to be invoked.

Import

Use this button to perform the import when the desired parameters have been entered.

When you select Import you will be given an Import Warning. This warning dialog is simply to remind you that import can overwrite existing data and should be used with caution. If you want to continue with the import simply hit return or the OK button.

If you wish to save the current version of the database before import or change the import parameters, hit the Escape key or the Cancel button to be returned to the import parameters dialog.

Recent Files

Select from the 4 most recently opened files.

XPX

XPX Format File

Select this option to import a file in XPX format. XPX format is designed to facilitate import of external databases into XP databases. The file format is described in detail in a separate documentation file. Basically, a simple command-line syntax is implemented to allow the creation of network elements and associated data.

The name of XPX format file may be entered manually or selected using the Select button.

See Also **XPX Command Reference** and Spreadsheet Import

XPX Command Reference

The format is described in pseudo-EBNF notation. Note that the file format is pure token stream; tokens are separated by white_space. Keywords (shown uppercase) are not case sensitive.

xpx_file = {command}

The XPX file consists of a series of commands with various parameters assigned to them to operate on. There are five types of XPX commands. They are :

1. **The node command**
2. The link command
3. The data command
4. The table command
5. The global database command

CONTEXT-SENSITIVE RULES:

Any references to objects must already be defined. ie. NODE commands must appear before LINK commands which reference them, and similarly DATA commands must appear after the object references are defined. An un-named global object is defined by an empty string (“”).

Notes:

1. Object names are not case-sensitive.
2. Strings with embedded white space can be enclosed in double-quotes (“).
3. Data can be commented out using 'C' style comments i.e. /* This is a comment */

XPX Node Command

COMMAND: NODE

DESCRIPTION: The node command defining a particular node must appear in the XPX file before any reference can be made to data or links associated with it. There is no rigid structure to the order that these command appear in provided the above rule is complied with. The node_command consists of the word NODE followed by a node_type, a node_name and an X and Y value which represent it coordinates

SYNTAX: NODE node_type Node_name X y

VARIABLES:

Node_type (Integer) The node_type is an integer value which specifies the shape the node will appear in its screen representation when the XPX file is imported. The various values and shapes for node_type are listed below.

Node Type	*Shape*
0	Circle
130	Arrow
132	Square
133	Triangle
134	Circle

Node_name (String) The node_name must be enclosed in double quotation marks. It is an alphanumeric string representing the name of this node and will appear adjacent to the screen representation of the node

X (Real) The X value is the horizontal plane coordinate (right is positive) used to locate the node object on the screen. This value may be a real world coordinate value or simply an arbitrary value to locate the node schematically. This is a real number of up to 20 significant figures. This number must be specified.

Y(Real) The Y value is the vertical plane coordinate (up is positive) used to locate the node object on the screen. This value may be a real world coordinate value or simply an arbitrary value to locate the node schematically. This is a real number of up to 20 significant figures. This number must be specified

EXAMPLE:	*command*	*node_type*	*node_name*	*X*	*Y*
	NODE	134	“mh a1”	45634.945	120341.012

XPX Link Command

COMMAND: LINK

DESCRIPTION: The link command consists of the word LINK followed by the link_type which specifies its screen appearance, the link_name, the node_from and the node_to.

SYNTAX: LINK link_type node_from node_to y

VARIABLES:

Link_type (Integer) The link_type is an integer value which specifies the type of line which will be used to represent the link on-screen. The link_type will determine whether this link (link_name) represents a sinkgle conduit (solid line) or multiple conduits or diversions (dashed line). The table below specifies the valid values for link_type and there meanings.

Link_type	*Line type*	*Conduit type*
0	Line	Single Conduit
136	Line	Single Conduit
137	Boldline	Single Conduit
138	Dashline	Diversion/Multi Conduit

Link_name (String) The link_name must be enclosed in double quotation marks. It is an alphanumeric string representing the name of this link and will appear on the screen representation of the link.

Node_from (String) The node_from parameter must be enclosed in double quotation marks. It is an alphanumeric string representing the name of the upstream connecting node for the link specified in link_name.

Node_to (String) The node_to parameter must be enclosed in double quotation marks. It is an alphanumeric string representing the name of the downstream connecting node for the link specified in link_name.

The node_from and node_to nodes must have been specified earlier in the XPX file using the NODE comand above. A link must be specified before any dat may be defined which is associated with the link

.	*command*	*node_type*	*link_name*	*node_from*	*node_to*
EXAMPLE:	LINK	136	“Link 1”	“mh a1”	“mh b1”

XPX Data Command

COMMAND: DATA

DESCRIPTION: The data_command is used to assign data attributes to objects (links and nodes) which have been defined earlier in the XPX file. It must begin with the word DATA and be followed by a field_name, and object_name to attach the data to, an instance , a count and data_string, the actual data being defined.

SYNTAX: DATA field_name object_name instance count {data_string}

VARIABLES:

Field_name (String) The data field_name is any name selected from the list in Section ? which is pertinent to this type of object, either link or node. The name is in quotation marks and is not case-sensitive.

The appropriate field name may be found in this reference or by using the “Get Field Info” facility in XP (using the **Dialog Icon**)

Object_name (String) The object_name is any quoted string which has been previously defined as a link or node using the LINK or NODE command. The data_string will be assigned to this object_name and placed in the database field called field_name. If the field_name is a global value and not associated with an object then the object_name is defined as a pair of double quotes (i.e. “”)

Instance (Integer) The instance is an integer value which allows for multiple instances of the same data type for the one object. For example, multiple conduits in one link. The first instance of a data type is assigned a value of 0 (zero). the second instance is 1 (one) and so on. For a data type which has only one instance the value will be 0 (zero).

Count (Integer) This value specifies how many data items to expect in the following data_string. Normally this is 1 (one) except for list data. For example, user inflow hydrographs have more than 1 (one) data point. If there were 25 points in the hydrograph you would specify a count of 25 and then follow with a data string containing 25 values.

Data_string (String) This is a string of value(s) which will be placed in the database field specified by the field_name string attached to the object specified by the object_name string. There must be as many data items in the data string as is specified by the value of the count variable and they must be separated by at least 1 (one) space.

EXAMPLE:

DATA	UIL	“Link1”	0	1	59.9
DATA	LIL	“Link1”	0	1	21.8

COMMAND: $TABLE ..... $TABLE_END

DESCRIPTION: The data_command is used to assign data attributes to objects (links and nodes) which have been defined earlier in the XPX file. It must begin with the word DATA and be followed by a field_name, and object_name to attach the data to, an instance , a count and data_string, the actual data being defined.

XPX Table Command

XPX format has been enhanced to allow the import of CSV files. The format of the file is as below:

The first line signifies the beginning of the table format. The second line contains all the XP variable names. The remaining lines (except the last) contains the object name, instance of data (usually 0), index (usually 1), and then the data for each variable.

SYNTAX:

$TABLE

{field_name_string}

object_name, instance, count, {data_string}

$TABLE_END

VARIABLES:

Field_name_string The field_name_string is any name pertinent to this type of object, either link or node. The name is not case-sensitive. Any number of variables can be included in the string.

The appropriate field_name_string may be found by using the “Get Field Info” facility in XP-SWMM (using the **Dialog Icon**)

Object_name (String) The object_name is any quoted string which has been previously defined as a link or node using the LINK or NODE command.

Instance (Integer) The instance is an integer value which allows for multiple instances of the same data type for the one object. For example, multiple conduits in one link. The first instance of a data type is assigned a value of 0 (zero). the second instance is 1 (one) and so on.

Count (Integer) This value specifies how many data items to expect in the following data_string. Lists cannot be entered in a table so the Count is always 1 (one).

Data_string (String) This is a string of values which will be placed in the database field names specified by the field_name_string. There must be as many data items in the data_string as are specified by the field_name_string. They must be separated by at least 1 (one) space or comma.

EXAMPLE: $TABLE

```
/* ,   ,   , DS Elev, US Elev, Length,  Depth, Rougnness, Width, Side 1,    Side 2 */
       ,   ,  ,  LIL,      UIL,      PLENG,    PDIA,      RMANN,     WIDE,     TTHETA,    TPHI
"LA5", 0, 1,    102.0,    102.5,    300,      9,         0.015,     0.0,      3.0,       3.0
"LA6", 0, 1,    101.5,    103.0,    300,      9,         0.015,     0.0,      3.0,       3.0
$TABLE_END
```

XPX Global Database Command

SYNTAX: GLDB

"gldb_type_name_string"

instance,

"gldb_name_string"

VARIABLES:

gldb_type_name_string — The gldb_type_name_string is the type of global database to be imported. The string must be enclosed in double quotes (").

Instance (Integer) — The instance is an integer value which allows for multiple instances of the same data type for the one object. For example, multiple database records. The first instance of a data type is assigned a value of 0 (zero). the second instance is 1 (one) and so on.

gldb_name_string — The gldb_name_string is the record name of global database to be imported. The string must be enclosed in double quotes (").

EXAMPLE:

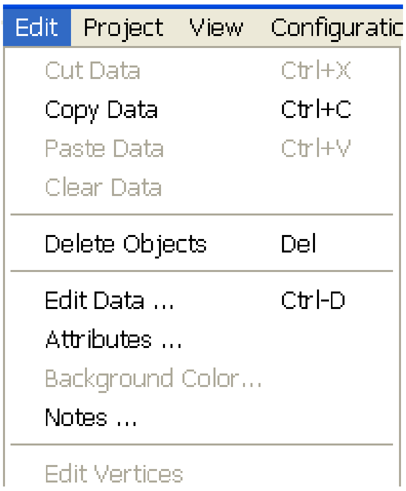
```
GLDB    "Inlet Ratings"    0    "IRC #1"
GLDB    "Inlet Ratings"    1    "IRC #2"
DATA    RATEX    0    2    10.000    30.000    70.000    /* Flow */
DATA    RATEX    1    3    4.000     5.000     12.000
DATA    RATEY    0    3    3.000     15.000    18.000    /* Captured Flow */
DATA    RATEY    1    3    2.000     2.200     3.000
```

Edit

THE EDIT MENU

The "Edit" menu lists commands for undoing, re-doing, and standard editing, plus some additional commands for copying and pasting selected node and link data.

This menu deals with management of both the graphical attributes and data associated with the network. This data comprises the attributes of network objects required by the specific model. For example, pipe diameters, catchment areas, plus text fonts, sizes, colours, etc.



Cut Data

Copy Data

Paste Data

Clear Data

Delete Objects

Edit Data

Attributes

Background Color

Notes

Edit Vertices

Cut Data

Performs a "Copy" and then a "Clear" operation on the currently selected link or node data. Data may be copied from one or multiple selected object(s). If multiple objects are selected, restrictions are placed on the "paste" command. See Section 4 for a more detailed description of this facility.

Copy Data

Copies the current selection into an internal buffer. This data is then available for "pasting" into a further selection of network objects. This "Copy-Paste" mechanism is an extremely effective way of generating data or making modifications to a large number of objects.

Paste Data

Copies the data from the internal buffer to the currently selected objects. For data to be successfully transferred between objects, both source and destination must be of the same class and type. Thus, circular node data can only be pasted into circular node data.

After the "Paste" operation, the number of objects and database records affected are reported. "Paste" cannot be undone in this version.

The copy buffer may be pasted into multiple objects by holding down the <Shift> key to make a multiple selection and then selecting "Paste" from the Edit Menu.

Data can also be pasted between databases. See Section 4 for a more detailed description of this facility.

Clear Data

Deletes all the attribute data from the current selection. The objects are left in an empty state, as if just created. The graphical attributes, such as name, colour, and line type are unaffected.

This operation can be undone. When attribute data is deleted it is not permanently erased and recovery is possible.

Delete Objects

Removes the current selection from the network and all associated database information. Note that from the definition of a link it cannot exist without end nodes; thus, removing either of a link's end nodes will remove the link also.

Note that this operation cannot be undone in the current version of XP.

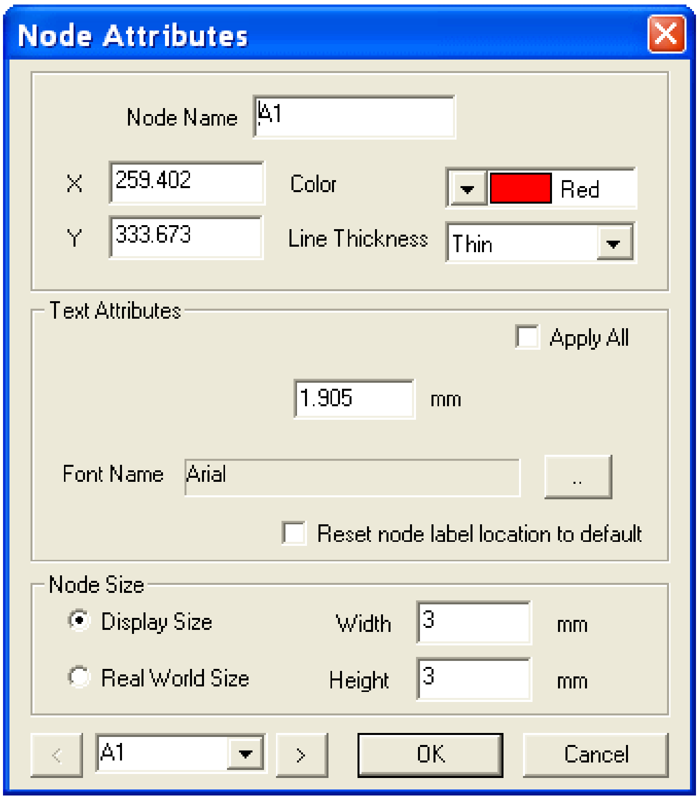
Edit Data

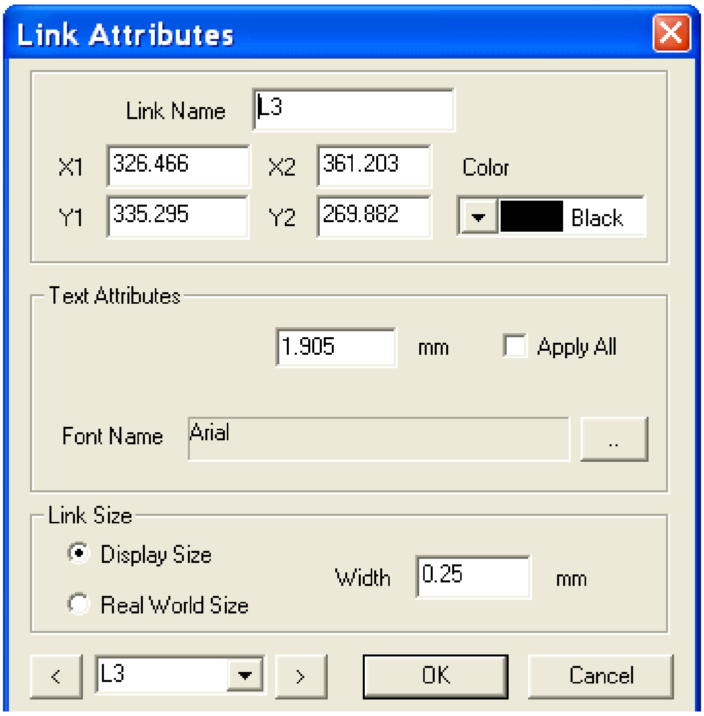
Allows direct editing of the link or node attribute data for the selected object. This is an alternative to "double-clicking" on an object with the mouse. Note that only a single object at a time can be edited this way.

The dialog that appears will depend on the current mode and whether a link or node has been selected. See Sections 8 and 9 for a complete description of Node and Link data.

Attributes

Allows editing of the name, coordinates and, display properties of the currently selected single object. All objects created must be given unique names. Depending on whether a node or link is selected, one of the following dialogs will appear.

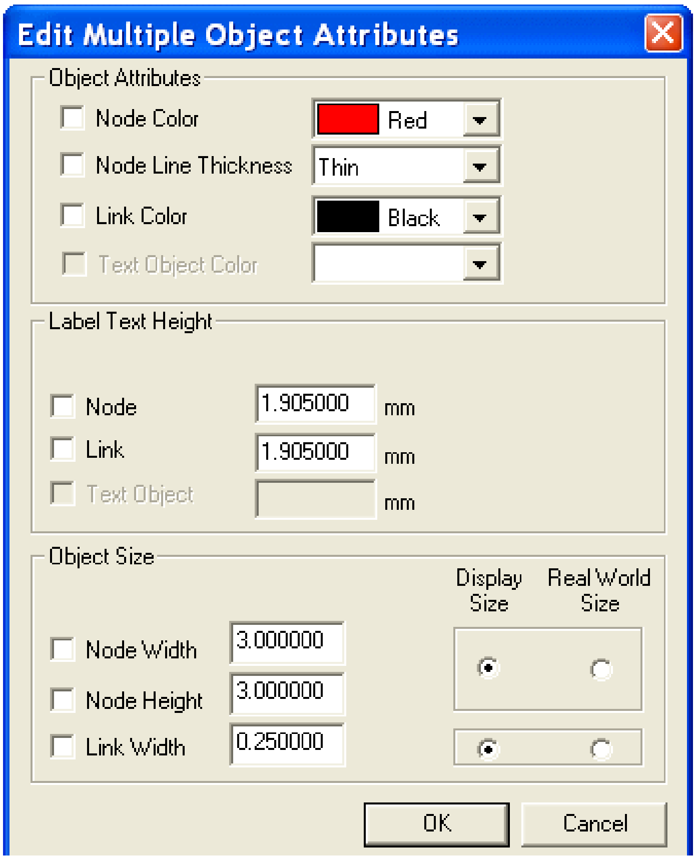




Font

Node Name

If multiple nodes, links or combinations of both are selected the dialog box will also allow graphical attributes to be altered.



Font

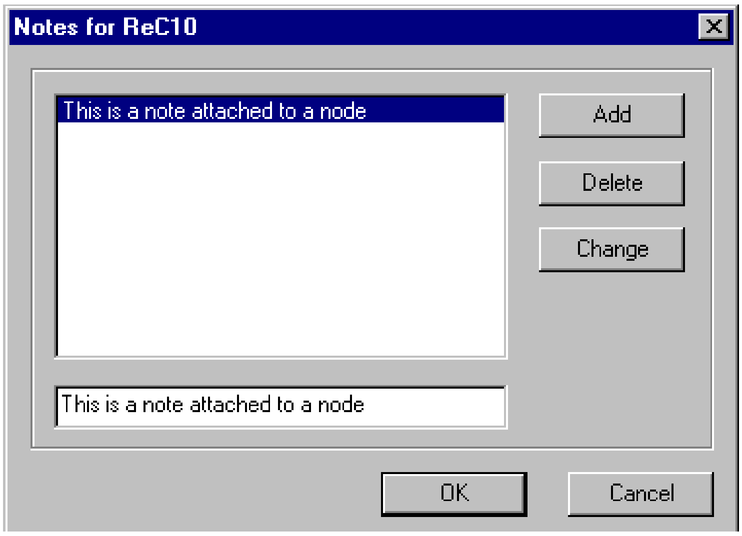
The normal Windows conventions regarding bitmap and true type fonts are supported. Select any available font.

Node Name

The node name must be unique and also different from the conduit names. The name is currently limited to 10 alpha-numeric characters.

Notes

A "notepad" is attached to each node and link. This notepad can be activated by selecting Notes from the Edit Menu, or Notes from the Pop-up menu. When Notes are selected a dialog similar to that shown below will be displayed.



A note is edited or added to the current list using the Edit field beneath the list of notes.

Add

Appends a note to the end of the list.

Insert

Inserts a note before the currently highlighted note.

Delete

Removes the currently highlighted note.

Change

Changes the currently highlighted note.

Edit Vertices

Project

THE PROJECT MENU

The Project Menu will only be active if the parameter PROJECTS=ON is present in the XP-RAFTS.INI file.

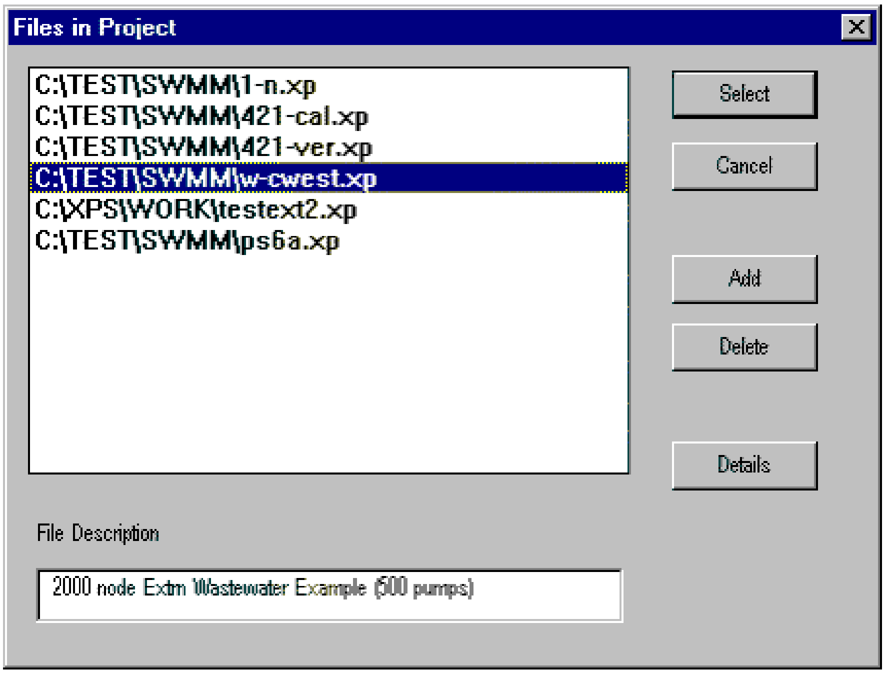
Projects are composed of files that are grouped together. The files are not interdependent in any way. An XP file can be included in different project groups.

When in Project mode the opening of files is restricted to project files only. Files can be added to and deleted from a project when the project is edited. On creating a new XP file or saving an existing file under another name it is automatically added to the project.

Multi-runs can be set up to solve a selection (or all) files in the project. If a current file is open it will be closed first. The selected files will then be loaded and the data checked for errors. If there are errors in the data then that data set will not be solved. After a multi-run has completed the last XP file to be processed by the multi-run is loaded. The results from the run are loaded for this file only. The results for the other XP files that were part of the multi-run are not updated to the XP file straight after a multi-run. The next time the file is opened the results from the multi-run are loaded.

Project files can also be loaded from the command line (when project mode is on).

If project management is enabled, the Open command under the File Menu will only list the files contained in the current project as shown in the following dialog.



New

Open

Edit

Close

Save

Save As

Multi-Run

Multi Review

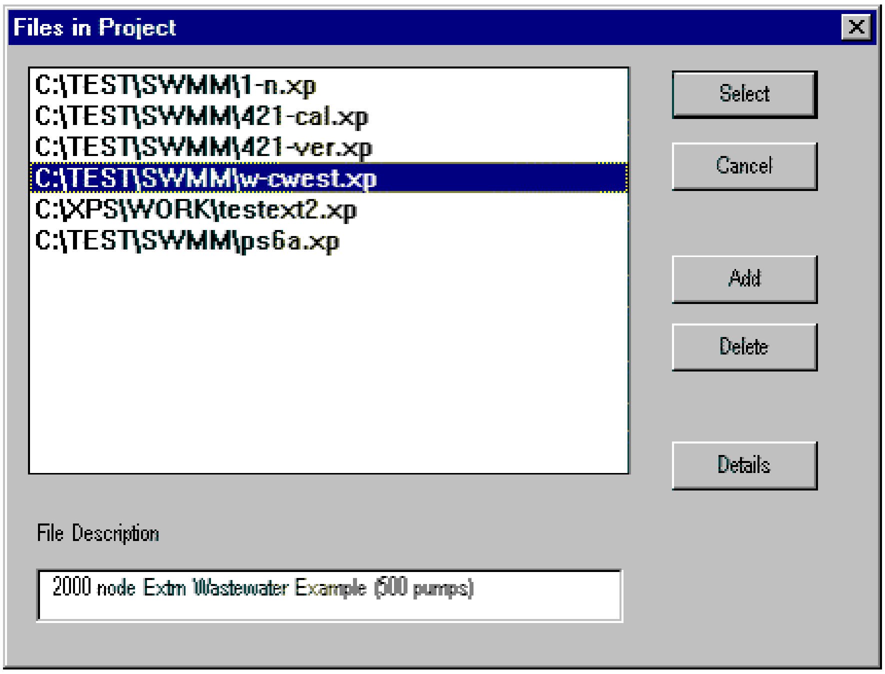
New

This menu command is used to create a new project database. Upon selecting this command a dialog box requesting the name of the new database appears. If the name of an existing project is entered, confirmation to overwrite it is requested and, if granted, the existing project is destroyed.

The program then proceeds to enable and disable appropriate menu commands. Only one project can be active at any one time. Although not mandatory it is good practice to give the new file a .XPP extension. This makes retrieval of the file more straightforward when using the "Open" command.

Edit

Use this item to add, delete or modify the files associated with the project. There are no limitations on the make-up of the project files. They can have any network configuration and can be located in any directory.



File Description

Enter a one-line description relating to the highlighted file.

Add

Select this button to show a list of XP files that may be added to the project. You can navigate your way through directories using the normal file selection process.

Delete

Select this button to delete the currently highlighted file.

Details

Close

Choose this option if you are finished with this project database and want to open another existing project or create a new one. If no changes have been made to the current project, it will be closed immediately, otherwise a "Save Project?" prompt will appear, allowing you the option of closing without saving changes, or cancelling the "Close" operation.

Save

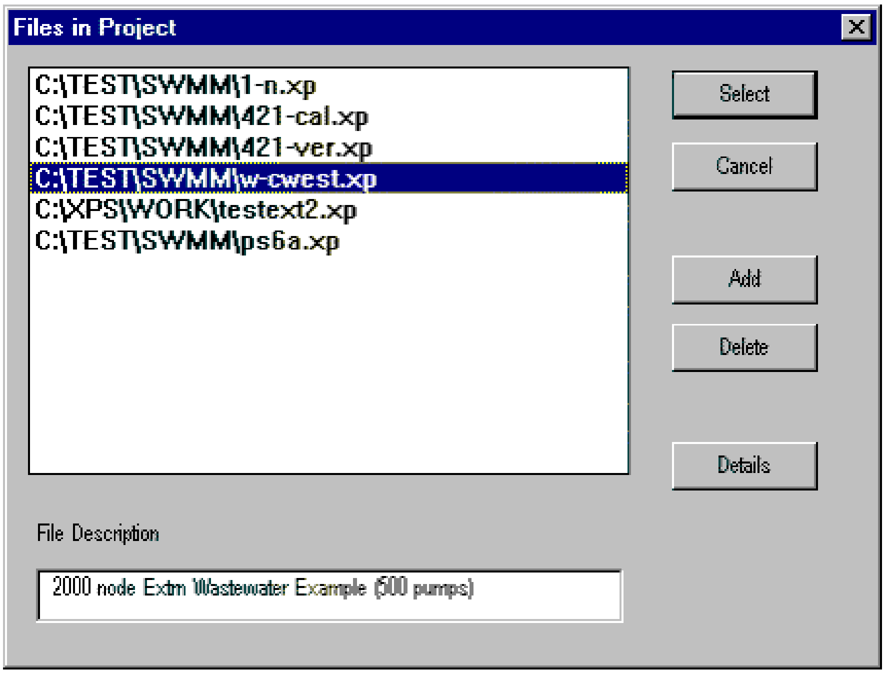
XP maintains an internal working copy of the database for editing sessions. Changes made while editing are not committed to the permanent database unless explicitly instructed by using the Save command. The Save command commits all changes made to the working database to the permanent database whose file name is the window title. The current view is also saved, so that when re-opened, the display will be in the same state as when the database was saved.

Save As

Copies of the working database (see Save command) can be saved under different names by issuing this command. A dialog box prompts for the new database name; the copy is then made and the new name becomes the current database.

The "Save As" and "Save" commands give you flexible control over the timing and permanence of data changes.

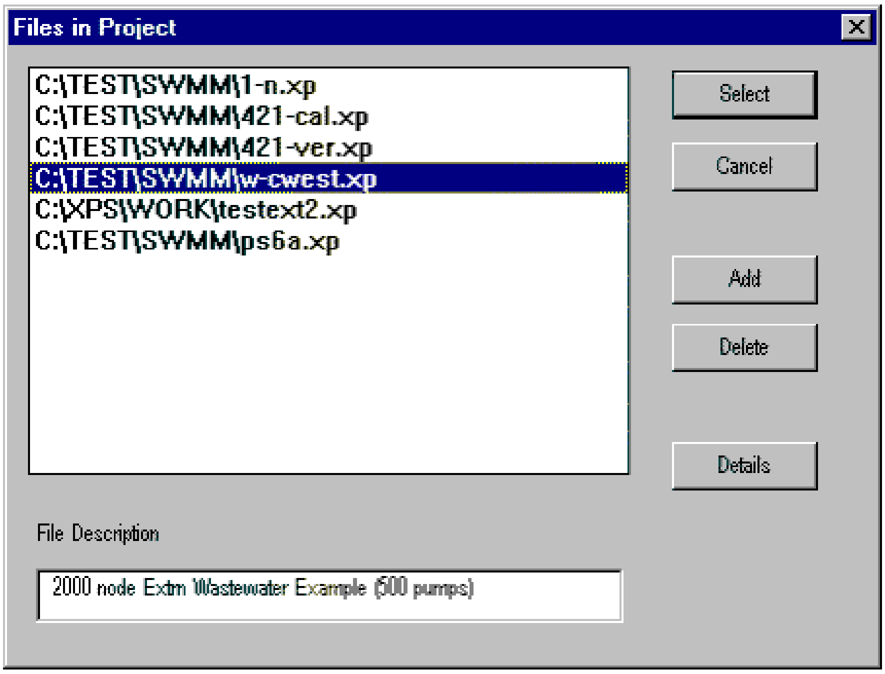
Multi-Run



Multi-run allows you to solve any (or all) of the files in the project in a single batch run. A highlighted file may be tagged or untagged by clicking on the file name

When Run is selected each tagged (highlighted) file is opened and solved (ie., the data file generated) in the sequence shown in the Project files list. If an error is encountered in generating the .DAT file the Multi-run is terminated and an error log describing the problem is created. If no errors are found the SWMM engine begins execution and each of the files is solved.

Multi-Run



Multi-run allows you to solve any (or all) of the files in the project in a single batch run. A highlighted file may be tagged or untagged by clicking on the file name

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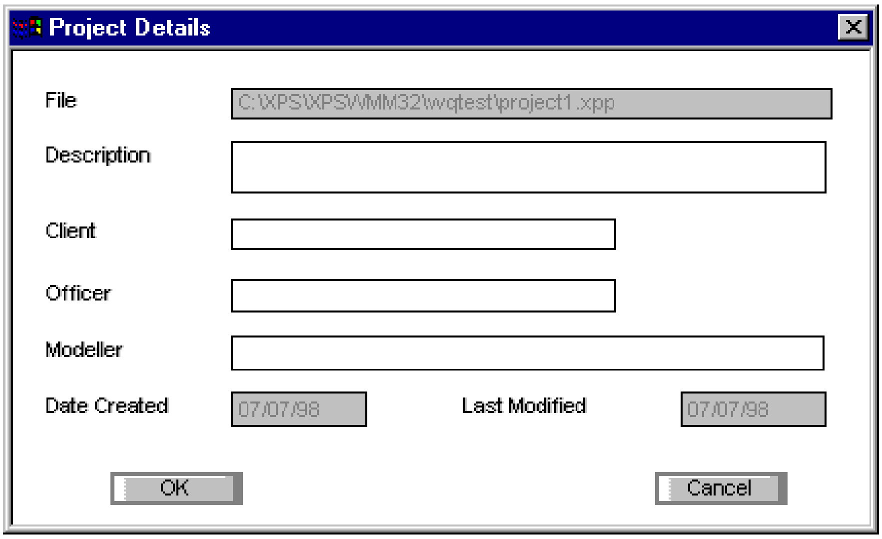
Details



The Description, Client, Officer and Modeler are alphanumeric strings used to describe the project.

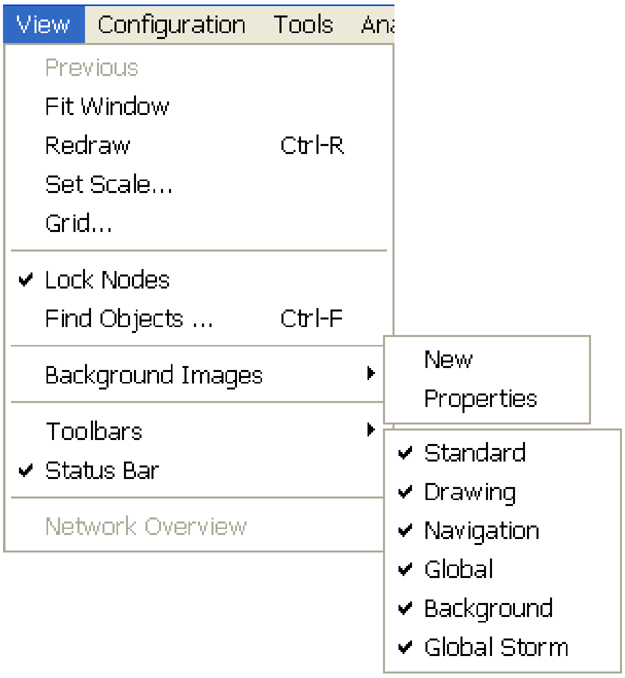
"Date Created" and "Last Modified" are set by the program and cannot be modified by the user.

View

THE VIEW MENU

The "View" menu enables rescaling and zooming of the displayed graph. Panning is handled by means of the scroll bars located at the bottom and right hand side of the screen or by other methods described in PANNING AROUND THE NETWORK Zooming is handled via the zooming tools, the "Scale" menu command or one of the methods described in RE-SCALING THE NETWORK WINDOW .

These menu commands, in conjunction with other mechanisms described in BUILDING THE NETWORK control your view of the network through the window shown on the screen. They help you "change your view" of the network.



Previous

Fit Window

Redraw

Set Scale

Grid

Lock Nodes

Find Objects

Background Images

- **New**
- **Properties**
- **ESRI Shape File Attributes**

Tool Bar

Status Bar

Network Overview

Previous

This command returns the display to the previous scale and location. It performs an "Undo" operation for viewing. This is a convenience method of toggling between a large-scale and small-scale view of the network.

Fit Window

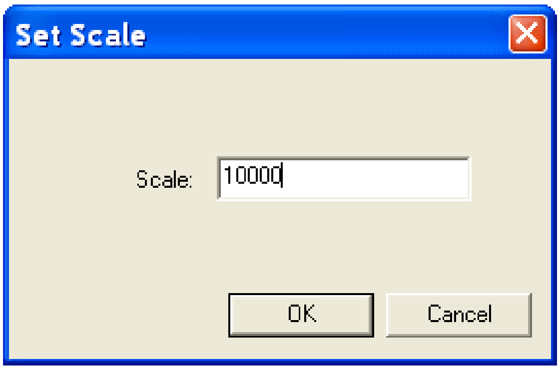
Select "Fit" to automatically rescale the network display to fit within the current window. The extremities of the network elements (the network's "world") are defined by a dotted outline which will be seen in full when a "Fit Window" is performed.

Redraw

Redraws the current screen. This command is useful for cleaning up a messy display following some object movements such as Pasting objects and when calculating areas and lengths using the polygon tool.

Set Scale

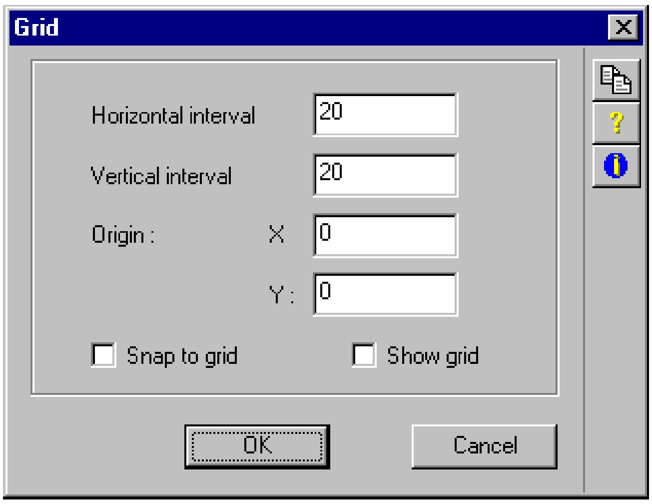
Allows the user to input a new scale via a dialog box. The scale value is an Engineering scale and can be considered an absolute value. Rescaling is done about the centre of the window.



Grid

The "Grid" command allows the user to specify a horizontal and vertical grid interval, the origin of the grid, whether objects should "snap" to the grid and whether the grid is visible.

The grid is shown as dashed lines and may be plotted using the "Export Graphics" menu command.

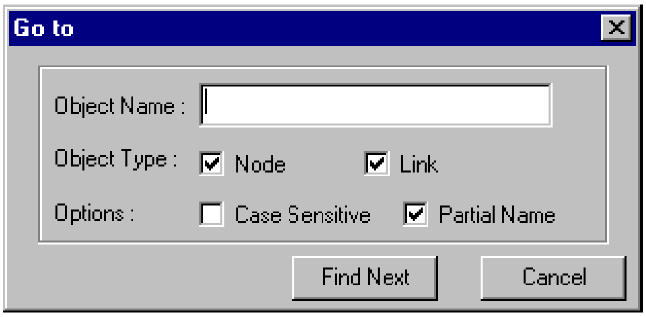


Lock Nodes

Toggles the ability to move nodes either with the graphical user interface or with Attributes dialog.

Find Objects

This command enables the user to go directly to any named object in the network. The user types in the name to search for and specifies whether it is link, node, text or whether it is case sensitive or only part of a name.



When OK is clicked the named object is searched for and, if found, it is highlighted and displayed in the centre of the screen at the currently selected scale.

Select Objects

Toolbar

The toolbar can be turned on or off by selecting this menu option. The toolbar can also be "torn off" the window and allowed to float or attached to one of the other window borders.

Status Bar

The status bar at the bottom of the window can be turned on or off by selecting this menu option.

Network Overview

Selecting the network overview brings up a thumbnail view of the entire network. Superimposed on this is a red rectangle, which indicates the view currently selected in the main window. You can move around the network by dragging the red box around the overview window with the left mouse button held down.

You can change the scale of the main window by holding the right button down and moving the mouse to the left to make the box smaller and increase detail in the main window, or to the right to show the network at a larger scale.

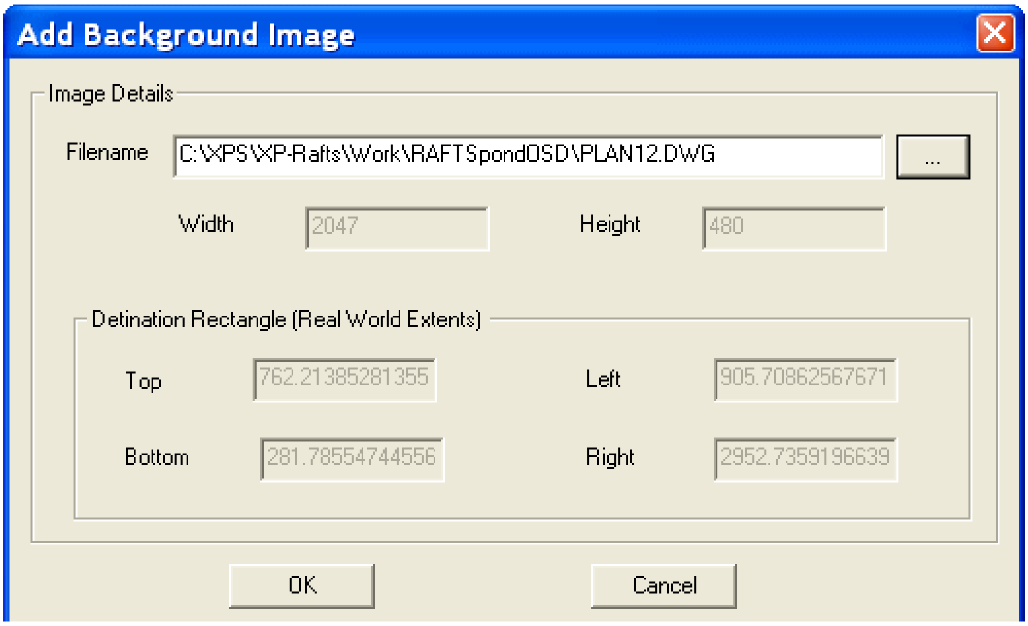
Background Image

Add Background Images

Pictures are stored as files on disk and only a reference to the file and the path is stored in the .XP file. These "Picture" files must be present for the background to be drawn. There is neither a limit to the number of background pictures that may be loaded into the network nor to the size of an individual picture. Pictures can be selected, deleted, moved, hidden, etc

Background picture types that are supported include: AutoCAD .DWG, and .DXF files, ESRI ArcView Shape files, MapInfo MID/MIF files, digital photos such as .BMP, .JPG, .TIFF, and HPGL (HPGL/1) files which must be translated to a .PIC (a native XP Software format) using the supplied converter CVTHPGL.EXE.

To launch the Add Background Image dialog, either select Background Image → New from the View menu or click on the New Background Image tool.



Click on the ellipses (…) to open a Windows Explore dialog and navigate to the background image file.

Real World Extents The outer corners (Top, Left, Bottom and Right) where the background image file resides. For non-CAD or Shape files these coordinates determine the aspect ratio and scale of the imported background.

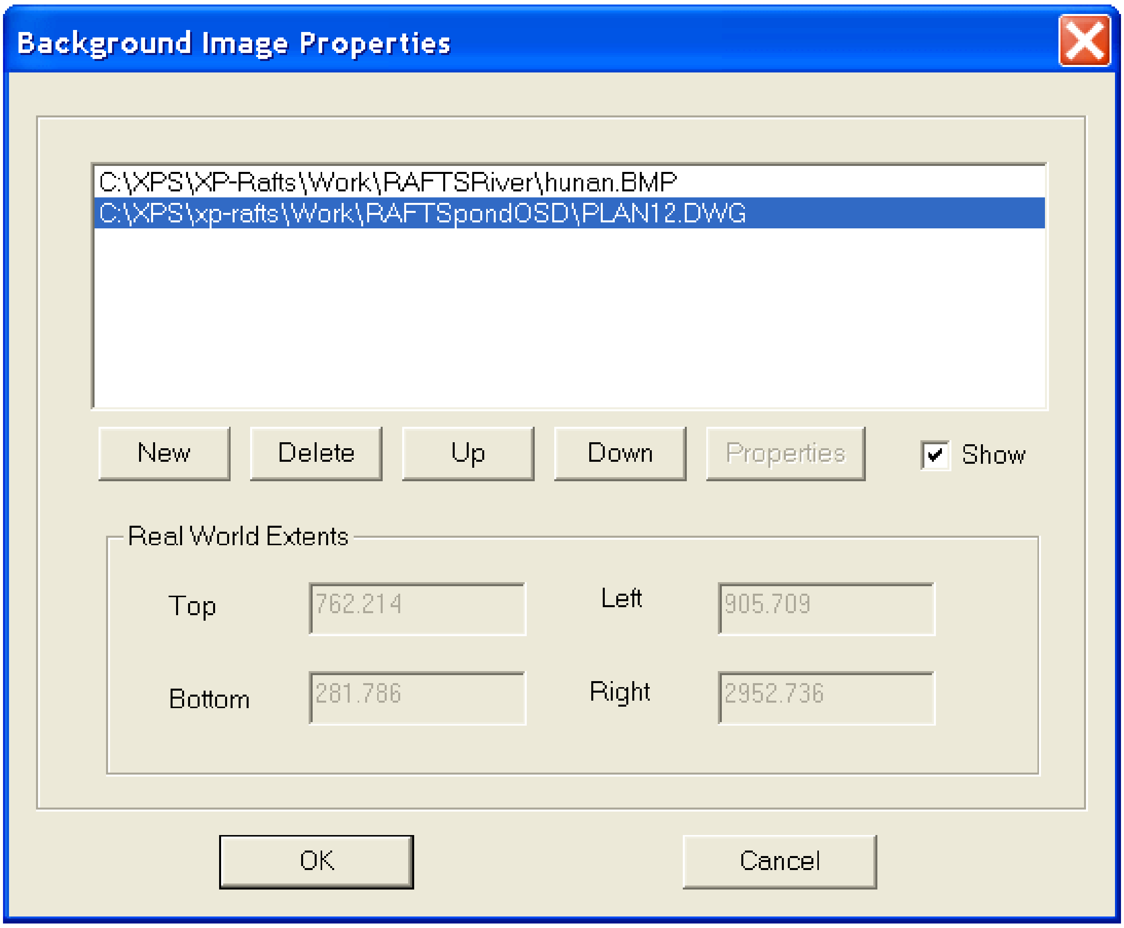
XP uses double precision coordinates with up to 20 significant figures. This enables map coordinates to be retained. Once a picture has been imported it is treated in the same manner as any other element of the network.

If an ESRI Shape file is selected then this button will open the ESRI Shape File Attributes dialog to allow attribute encoding.

In general, background pictures can be manipulated in the same way as any other network object, with the exception that the <Ctrl> key must be used in conjunction with any other action. Thus, pictures can be selected, deleted, moved, hidden, etc. A picture may be re-scaled isotropically by holding down the <Shift> and <Ctrl> keys. See Sections 2.4 and 2.13 for further information.

Background Image Properties

To edit existing background images select Background Images->Properties from the View menu or choose the Image Properties icon from the toolstrip.



New This button will open the Add Background Image dialog.

Delete This button will delete the highlighted background picture from the XP database.

Up This button will move the selected background picture up one level in the list.

Down This button will move the selected background picture up one level in the list.

Properties If an ESRI Shape file is selected then this button will open the ESRI Shape File Attributes dialog to allow attribute encoding.

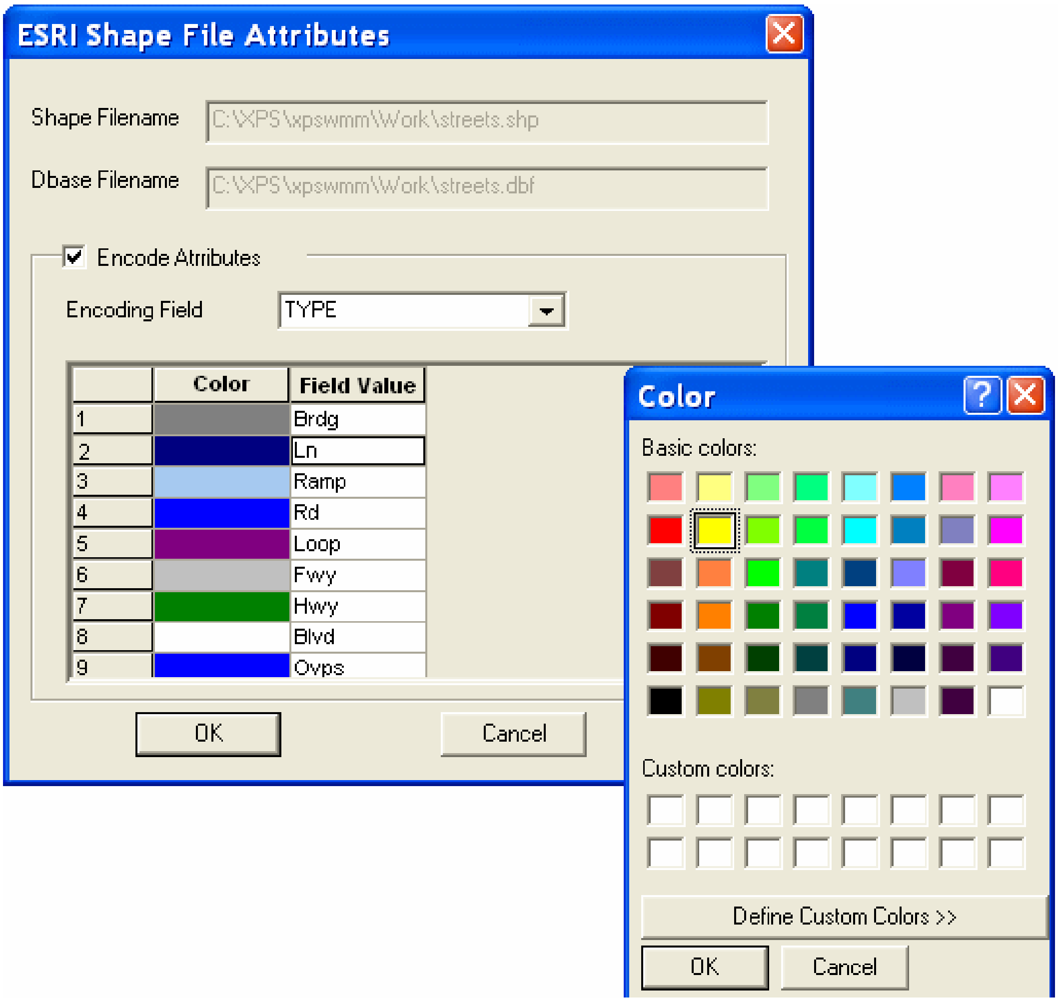
Show This button will toggle the display or hiding of the selected background picture.

Real World Extents The outer corners (Top, Left, Bottom and Right) where the background image file resides. For non-CAD or Shape files these coordinates determine the aspect ratio and scale of the imported background.

xprafts uses double precision coordinates with up to 20 significant figures. This enables map coordinates to be retained. Once a picture has been imported it is treated in the same manner as any other element of the network.

ESRI Shape File Attributes

Use this dialog to define the color coding of attributes of an ESRI Shape File.



Shape Filename The name of the Shape file that is being Encoded.

Dbase Filename This is the name of the database file that contains the attributes being encoded.

Encode Attributes This is a checkbox to turn on/off the encoding of the selected attribute.

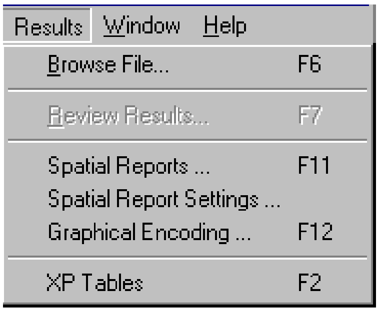
Encoding Field This combo box allows the user to select the attribute in the database file for encoding.

Color This is a column of colors assigned to the field value of the same row. Selecting the on the cell brings up the Windows Color palette shown below.

Field Values This is a column of the selected attributes from the database file. To the right is the color assigned to that shape file element.

Results

THE RESULTS MENU



Browse File

Review Results

Spatial Report

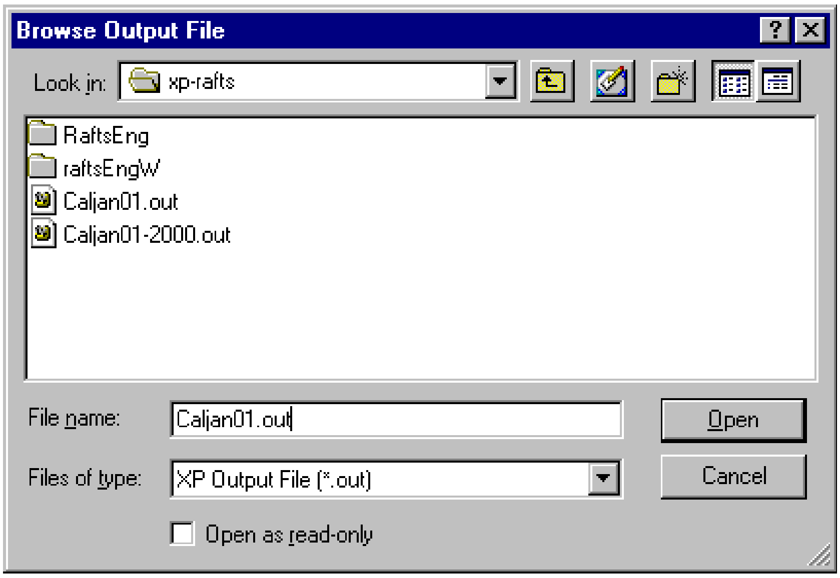
Spatial Report Settings

Graphical Encoding

XP Tables

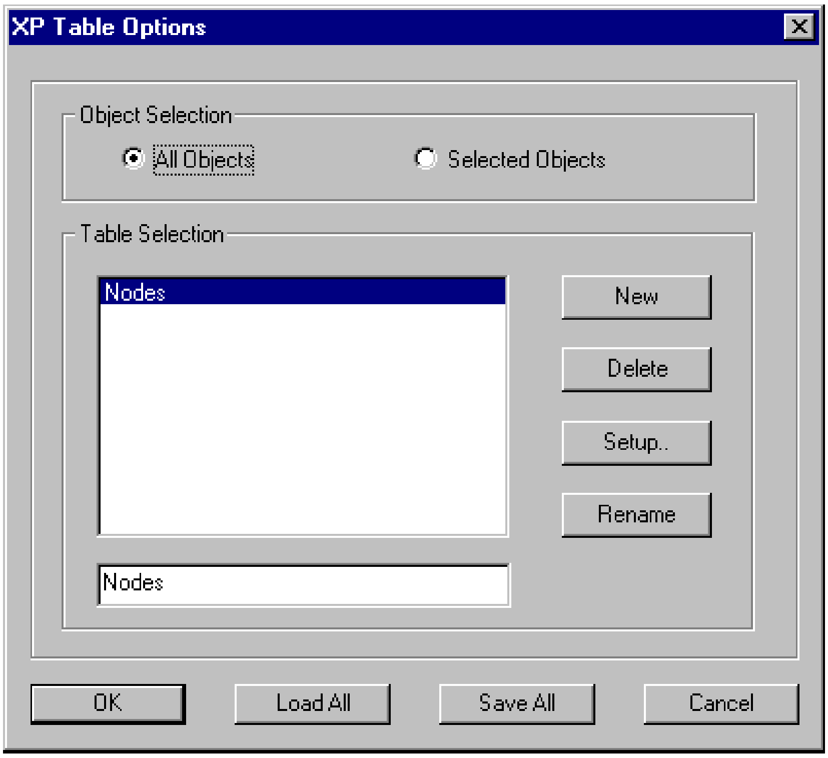
Browse File

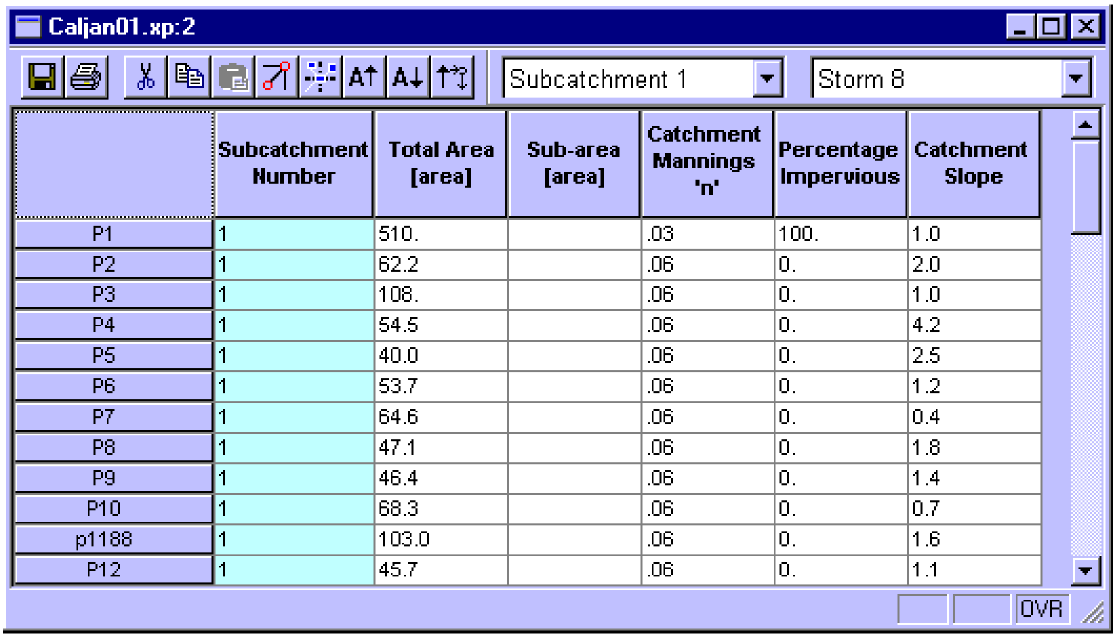
This command allows the user to browse any text file on the system. This command is intended to allow users to view their output files without leaving the XP environment but can be used for any ASCII text file.



When you select a filename Notepad.exe, or the editor referred to in XP-RAFTS.INI will be loaded. See the Help menu of your selected editor for more information.

XP Tables

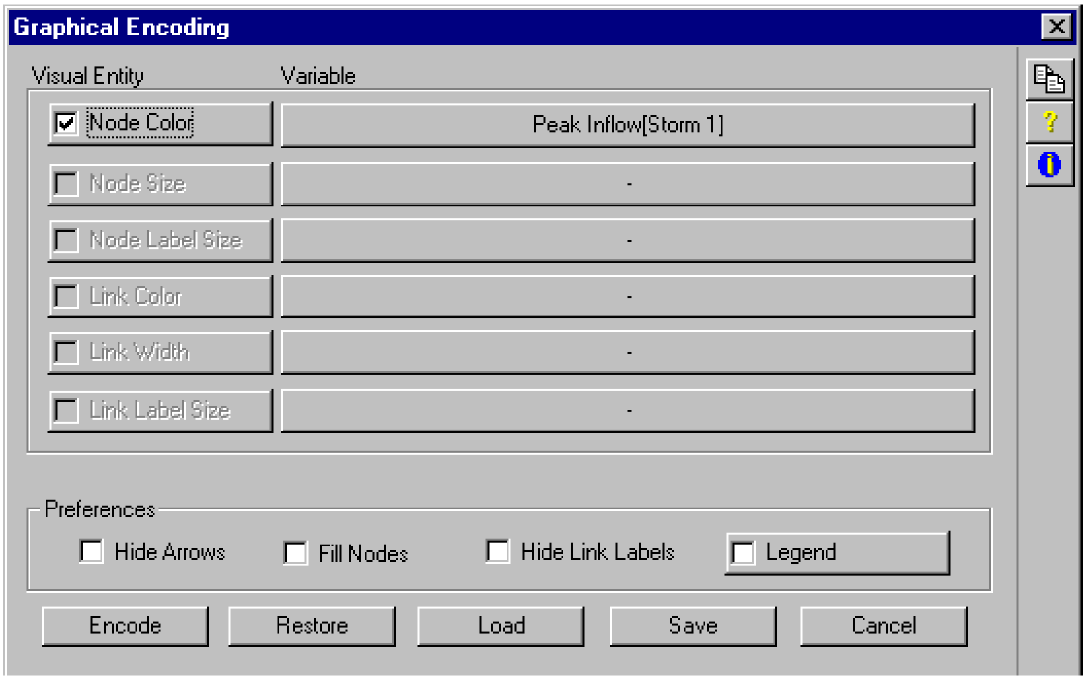




	Subcatchment Number	Total Area [area]	Sub-area [area]	Catchment Mannings 'n'	Percentage Impervious	Catchment Slope
P1	1	510.		.03	100.	1.0
P2	1	62.2		.06	0.	2.0
P3	1	108.		.06	0.	1.0
P4	1	54.5		.06	0.	4.2
P5	1	40.0		.06	0.	2.5
P6	1	53.7		.06	0.	1.2
P7	1	64.6		.06	0.	0.4
P8	1	47.1		.06	0.	1.8
P9	1	46.4		.06	0.	1.4
P10	1	68.3		.06	0.	0.7
p1188	1	103.0		.06	0.	1.6
P12	1	45.7		.06	0.	1.1

Graphical Encoding

Graphical Encoding, often also called thematic viewing or plotting, allows variables (or themes) to be displayed using graphical entities of objects. Currently three entities are supported for both links and nodes. These are; Colour, Size or Width, and Text Label Size. The variables (or themes) include all input data plus selected results of the RAFTS analysis.



Visual Entity. Three graphical entities, color, size and text height, are available for each of the two object types.

Node Color

Node Size

Node Label Size

Link Color

Link Width

Link Label Size

Variable

Preferences

Encode

Restore

Load

Save

Cancel

Configuration

THE CONFIGURATION MENU

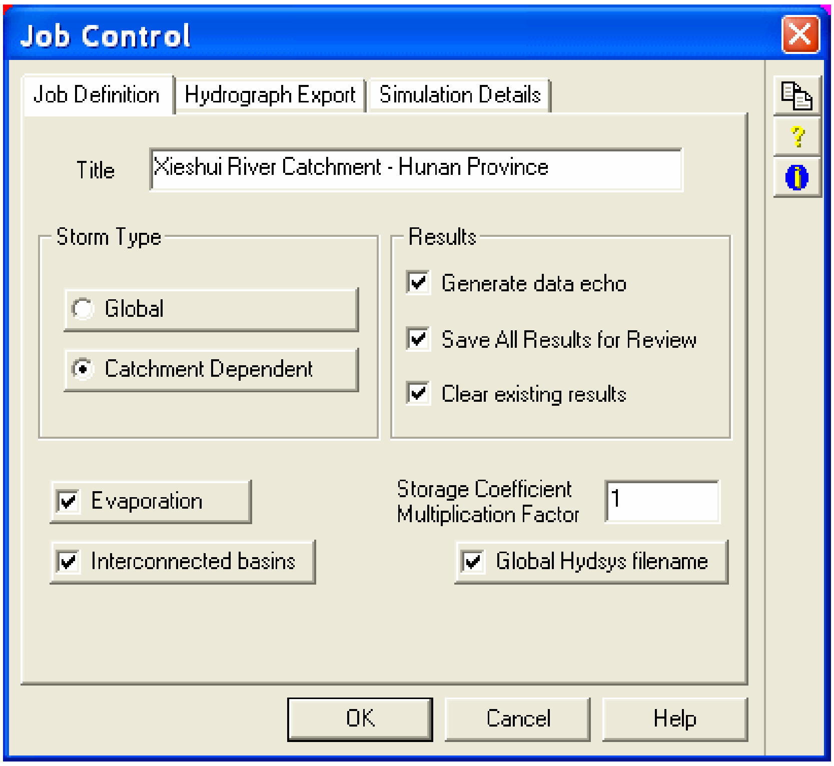
Job Control

Global Data

Units

Job Control

The "Job Control" command allows the management of Control Data associated with the specific application. The data is global and not specific to any individual object.

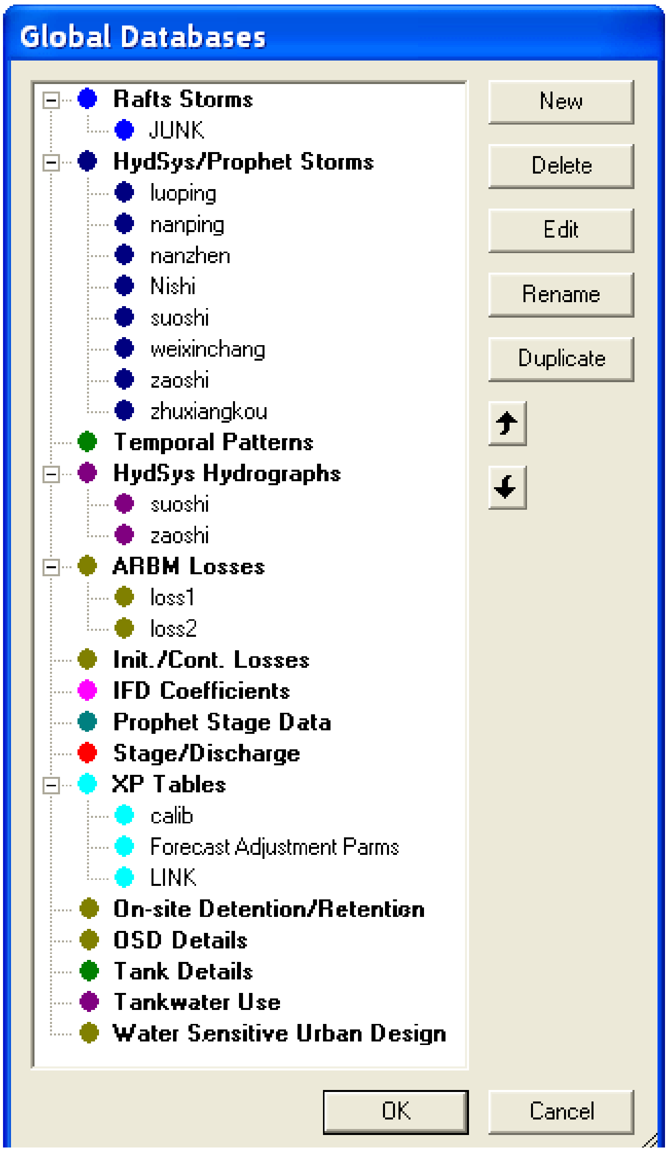


A full description of the parameters used by xprafts is provided in Section 10 - Job Control **.** A complete description of the solution technique is provided in **Section 13 - Rafts Theory** .

Global Data

Global databases are records of data, which provide an environment for the whole network. They allow the editing of databases which are global to the network and which can be referenced from any objects within the network. This feature allows common data to be shared amongst many objects and thus reduces redundancy of data dramatically.

This dialog is used to manage the Global Databases.

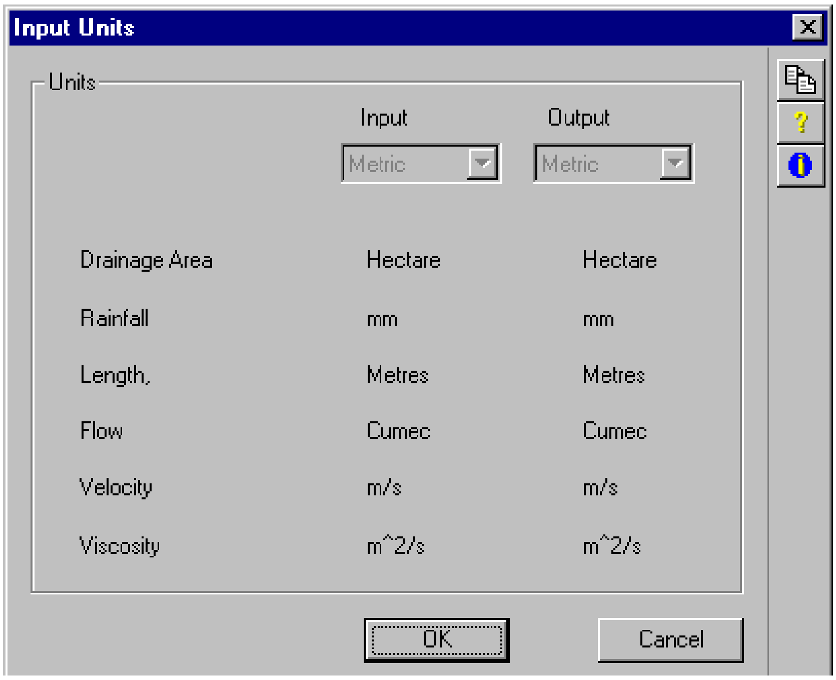


Toggle the +/- box to expand/collapse the list of global databases. Use the vertical slider bar or resize the dialog window to view the complete list.

Use the buttons in the right column create, edit and delete Global Database records.

Units

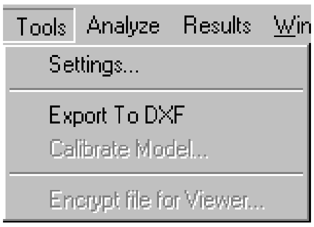
This Dialog allows you to select between Metric and U.S. Standard units for the model. When a NEW database is created, the units will be prompted for. If units are changed after a database is created, then data conversions are NOT done. It is important to set the units expected to be used at the time a database is created.



Tools

THE TOOLS MENU

The "Tools" menu lists commands that are not part of the generic XP interface but are specific to individual applications, in this case XP-Rafts2000.



Settings

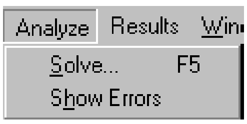
Export To DXF

Calibrate Model

Encrypt for Viewer

Analyze

THE ANALYZE MENU



Solve

Show Errors

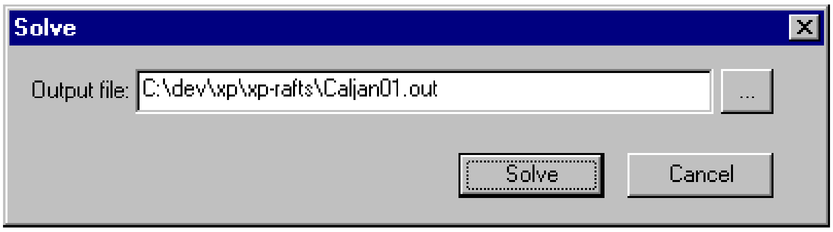
Solve

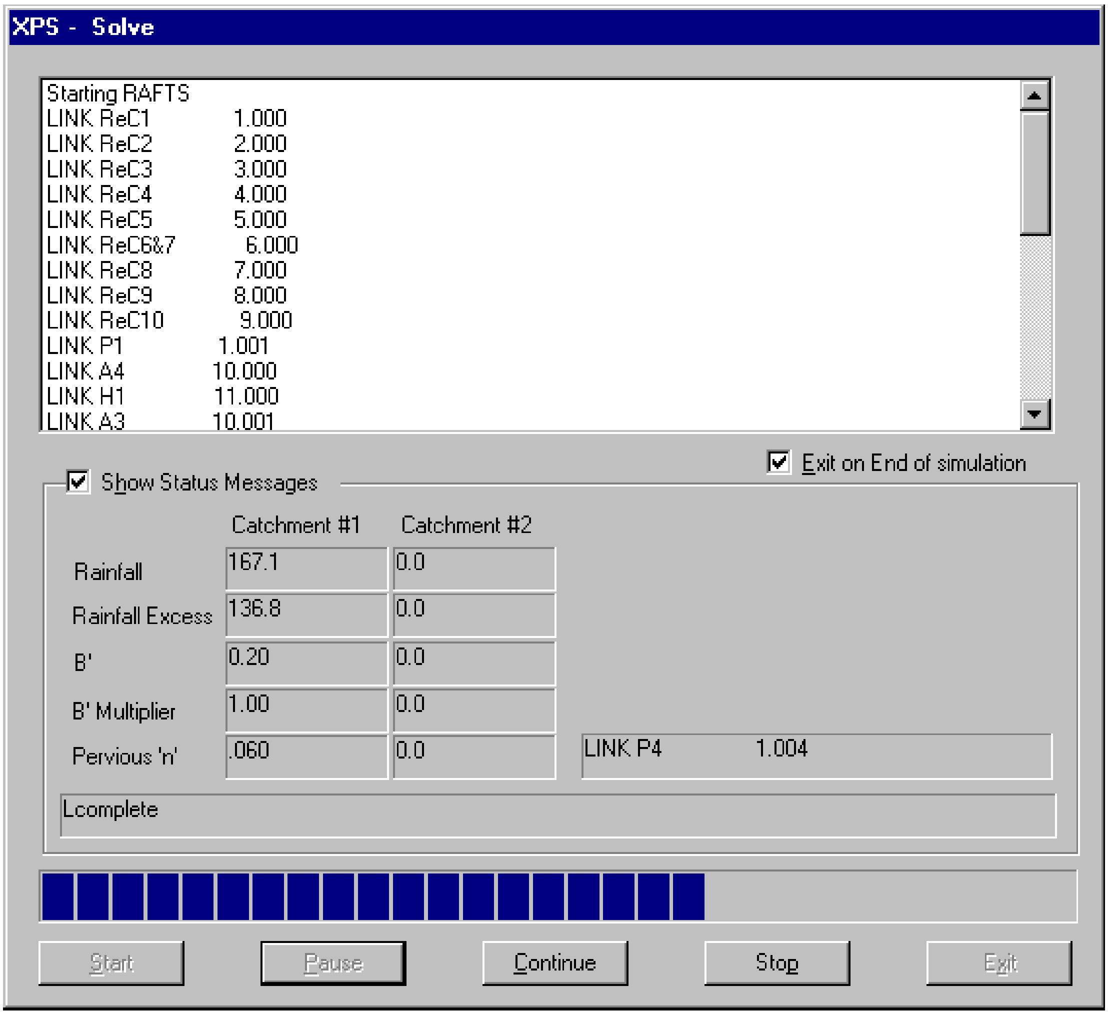
This menu command is used to commence analysis of the network. The data is first checked for consistency and, if it is found to be sound, the network can be analysed and the analysis engine is invoked. Otherwise a window showing all the data inconsistency errors is displayed. The errors and warnings shown may be re-displayed by selecting the "Show Errors " menu command.

The mandatory consistency checks performed at this stage generally concern relationships between data items and are outlined in more detail in Section 13.

If no errors or warnings are detected no error log is generated. The user is next prompted for the name of a text-based output file. The default name will be the database file name with a .out extension.

When **Solve** is clicked the analysis engine is loaded and when the analysis is complete any errors or warnings encountered are reported.





Show Errors

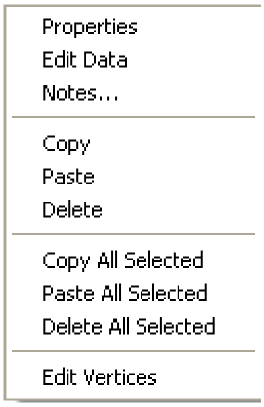
Show Errors will re-display the "error.log" file that is created when a network is solved. This enables the user to systematically correct any errors encountered without the need to print the error log or to re-solve the network.

Pop-Ups

THE POP-UP MENUS

Pop-up menus provide shortcuts to some of the more commonly used menu commands.

To use the pop-up menu commands click the right mouse button on the object (node, link or diversion) to be altered. The content of the pop-up menu will depend on the type of object selected. The appropriate menu item is then selected in the normal way. To cancel the pop-up menu, click outside the region of the menu.



Node Pop-up Menu **Link Pop-up Menu** **Diversion Pop-up Menu**

When a display attribute for a single object is modified, the change is local to that object. When the display attributes for a tool are modified any subsequently created objects of that type inherit the tool's characteristics, but previously created objects do not.

Notes can be added or altered from the pop-up menu and a bitmap image attached to the node as a Picture File can be displayed using the View Image command.

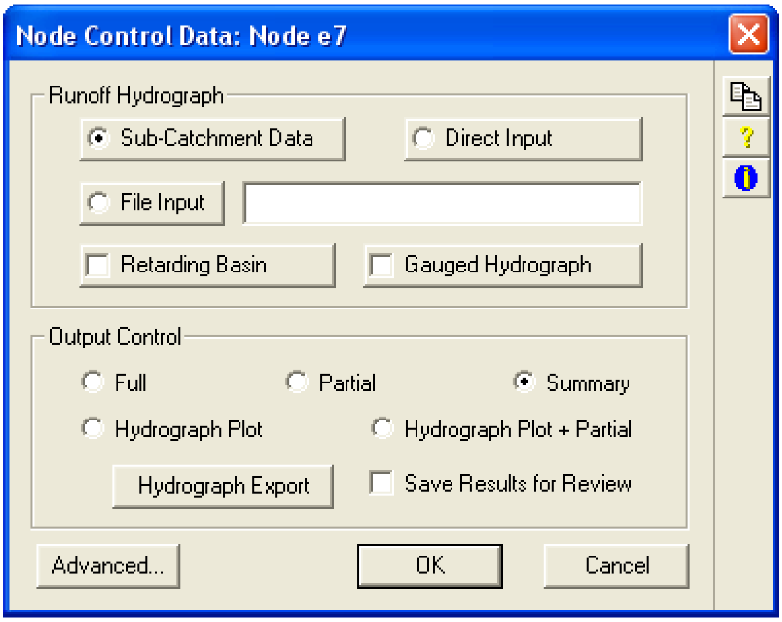
A link type may be changed from a Single Conduit to a Multiple Conduit or vice versa by selecting the appropriate item from the pop-up menu.

Note: If a link is already selected and the <Ctrl> key is held down and the link clicked on with the mouse, the link will change to a Polylink and a vertex will be inserted at the location where the mouse was clicked. Ensure the link is <u>not</u> highlighted before attempting to pop-up a menu.

8 - Node Data

NODE DATA

To input or edit the attribute or model specific data associated with a node either "double-click" on the node, select the node and choose the "Edit Data" command from the Edit Menu. The hierarchy of the dialog boxes is navigated by clicking on various button items within dialogs. The layout below indicates the layout for any node of the network.



Sub-Catchment Data

Direct Input

File Input

Retarding Basin

Gauged Hydrograph

Hydrograph Export

Node Data

A node in xprafts represents a junction of two or more links and the drainage point of a sub-catchment in the drainage system. Links and diversions are connected to these objects to create a drainage network.

Computed (LRRM)

Hydrographs can calculate either surface stormwater flows or sewage flows from both dry weather and wet weather sources.

STORMWATER MODELLING

When rural stormwater flows are being considered only it is usual to only have one (1) sub-catchment entering a node. Catchment area is input in hectares.

When urban stormwater runoff is being analysed two sub-catchments should be included to a node. These should individually reflect the pervious and impervious contributions respectively. Both catchment areas are input in hectares.

SEWER MODELLING

When sewage flows are being analysed the split catchment option should be utilised to separately estimate the dry weather and wet weather (infiltration) contributions to the node. In this instance the Catchment area for wet weather infiltration is input in hectares.

Dry weather flow catchment area is HOWEVER NOT INPUT IN HECTARES. To reflect an instantaneous diurnal dry weather flow pattern it is necessary to input as catchment area EP divided by 10,000 ie. Catchment area input = EP / 10,000

Appropriate flow values per EP for the sub catchment together with an appropriate dimensionless diurnal temporal pattern is provided in the global storm database under Global Menu.

It is usual to use the first sub-catchment to determine dry weather flow and the second sub-catchment to estimate both direct and infiltration wet weather flow.

Direct Input

Hydrographs may be input directly by the user in one of two ways:

1. By directly specifying the hydrograph coordinates in the table displayed when the "Direct Input" button is selected, or
2. By specifying a disk file from which the hydrograph coordinates are read. This option is chosen by selecting the "File Input" button.

The following indicates the format specifications of the ASCII text file for both local and total upstream hydrographs. This file is also generated when the RAFTS Local Hydrograph or RAFTS Total Hydrograph options are chosen under “Hydrograph Export” at a node.

Start of File

JOB, NLKS, NVAL, DT (3i5, g12.5)

			Repeat
Repeat next two lines for NLKS links			for each
Linkno.	Linklab	(g10.2, a10)	stacked
			storm
Q(k),	I = 1, nval	(5g12.5)	

End of File

JOB	Storm event number
NLKS	No of tagged links in file
NVAL	No of routing increments in minutes
DT	Length of routing increment in minutes
Linkno	Link number of tagged hydrographs
Linklab	Hydrograph ordinates in m3/s
Note:	All hydrographs refer to input to the top of the link before basin routing.

Runoff Hydrograph

Runoff Hydrograph Options

Retarding Basin

All the information describing the retarding basin or on-site storage at this node is entered by selecting this button.

Gauged Hydrograph

A gauged hydrograph may optionally be entered for comparative display against a computed hydrograph when undertaking calibration or verification.

Full Output

The Full Output option provides extensive results in the text output file created during the execution of RAFTS. This option provides more detail than is generally required, however if a particularly complex simulation is being performed this option may be useful to monitor the intermediate results.

Not recommended for general use as level of detail is more than required.

Partial Output

The Partial Output option provides a useful level of detail without an excessively large output file.

This option is recommended for nodes which are defined as retarding basins or storages.

Summary Output

The Summary Output option provides a reasonable level of detail for most situations which do not have storages defined.

This option is recommended for nodes without basins.

Hydrograph Plot

This option provides a text hydrograph plot for this node in the output file. This option has been superseded by the Review Results feature of the xprafts environment and is not required for plotting hydrographs.

Not recommended for general use.

Hydrograph Plot + Partial

This option provides a text hydrograph plot and partial output for the current node in the output file. This option has been superseded by the Review Results feature of the xprafts environment and is not required for plotting hydrographs.

Not recommended for general use.

Hydrograph Export

Option to define estimated hydrographs file output.

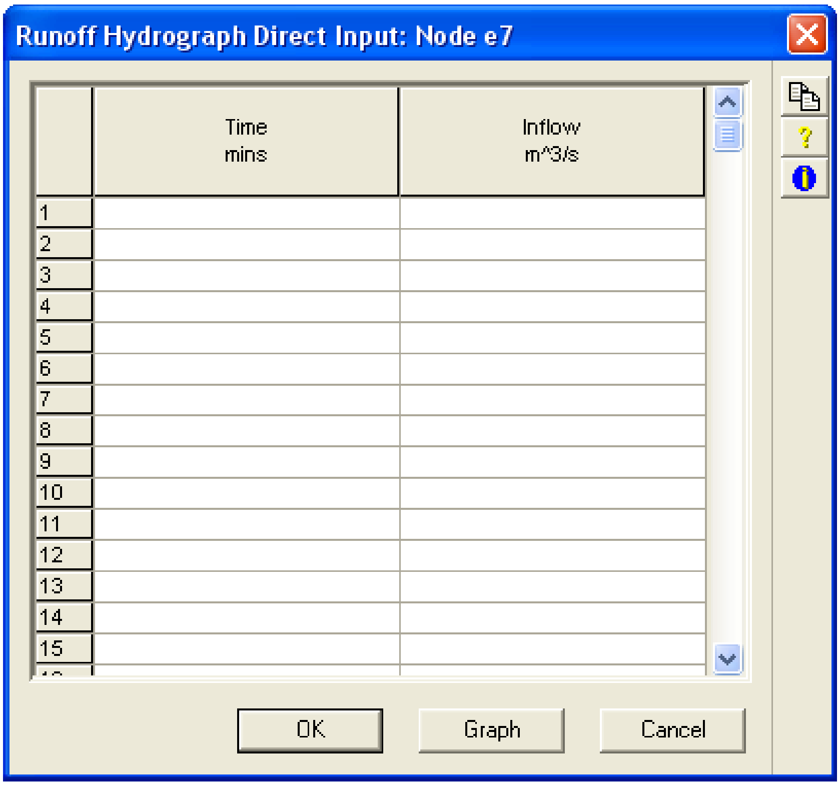
Save Results for Review

If this flag is on output from this node will be saved to a file to allow graphical post-processing. Post-processing can be performed via the Review Results menu command (after the network has solved). This flag may be over-ridden by a global flag in Job Control.

Output Control

Output Control is used to set the level of detail for printing in the text output file. In most cases Full Output is not necessary but may be useful in difficult situations. Partial output is useful for nodes which have storages defined but in general summary output is of sufficient detail. This is particularly the case when Review Results is utilised.

Direct Input



Direct Input

Time

Time in minutes corresponding to instantaneous inflow discharge value. The first time MUST be zero.

Inflow

Inflow discharge in m^3/s running off total sub-catchment. Inflows must be non-negative.

File Input

Direct Input

Hydrographs may be input directly by the user in one of two ways:

1) By directly specifying the hydrograph coordinates in the table displayed when the "Direct Input" button is selected,

OR

2) By specifying a disk file from which the hydrograph coordinates are read. This option is chosen by selecting the "File Input" button.

The following indicates the format specifications of the ASCII text file for both local and total upstream hydrographs. This file is also generated when the RAFTS Local Hydrograph or RAFTS Total Hydrograph options are chosen under "Hydrograph Export" at a node.

Start of File

JOB, NLKS, NVAL, DT (3i5, g12.5)

			Repeat
Repeat next two lines for NLKS links			for each
Linkno.	Linklab	(g10.2, a10)	stacked
			storm
Q(k),	I = 1, nval	(5g12.5)	

End of File

JOB	Storm event number
NLKS	No of tagged links in file
NVAL	No of routing increments in minutes
DT	Length of routing increment in minutes
Linkno	Link number of tagged hydrographs
Linklab	Hydrograph ordinates in m3/s
Note:	All hydrographs refer to input to the top of the link before basin routing.

Output Control

Full Output

The Full Output option provides extensive results in the text output file created during the execution of RAFTS. This option provides more detail than is generally required, however if a particularly complex simulation is being performed this option may be useful to monitor the intermediate results.

Not recommended for general use as level of detail is more than required.

Partial Output

The Partial Output option provides a useful level of detail without an excessively large output file.

This option is recommended for nodes which are defined as retarding basins or storages.

Summary Output

The Summary Output option provides a reasonable level of detail for most situations which do not have storages defined. This option is recommended for nodes without basins.

Hydrograph Plot

This option provides a text hydrograph plot for this node in the output file. This option has been superseded by the Review Results feature of the RAFTS-XP environment and is not required for plotting hydrographs.

Not recommended for general use.

Hydrograph Plot + Partial

This option provides a text hydrograph plot and partial output for the current node in the output file. This option has been superseded by the Review Results feature of the RAFTS-XP environment and is not required for plotting hydrographs.

Not recommended for general use.

Hydrograph Export

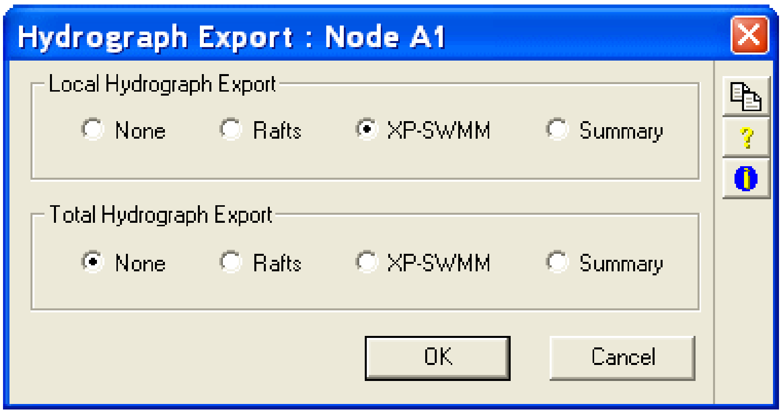
Option to define estimated hydrographs file output.

Save Results for Review

If this flag is on output from this node will be saved to a file to allow graphical post-processing. Post-processing can be performed via the Review Results menu command (after the network has solved). This flag may be over-ridden by a global flag in Job Control.

Hydrograph Export

Define options exporting hydrographs for the selected node. Local and/or Total hydrographs may be exported at any node in an xprafts ASCII format or in the xpswmm binary format. Use the Hydrograph Export tab in the Job Control settings to enable the creation of the output file(s) and to set the locations of the exported files. Files are exported when the model is solved.



The **Local Hydrograph Export** includes all runoff entering the node.

The **Total Hydrograph Export** is the sum of the Local Hydrograph and the flow from upstream nodes.

The export options are:

None	No local hydrograph is generated for this node
Rafts	ASCII format file is generated for this node
xpswmm	Binary file is generated for this node.
Summary	A summary of results at all nodes in generated in ASCII format.

The following indicates the format specifications of the ASCII text file for both local (*.loc) and total (*.tot) hydrographs.

Start of File

Sample	1	3	600	0.20000
Description	Stacked Storm No.	No of tagged nodes	No of routing increments	Length of routing increments, mon

For each tagged node:

Sample	1.0020	286
Description	Job	Node ID

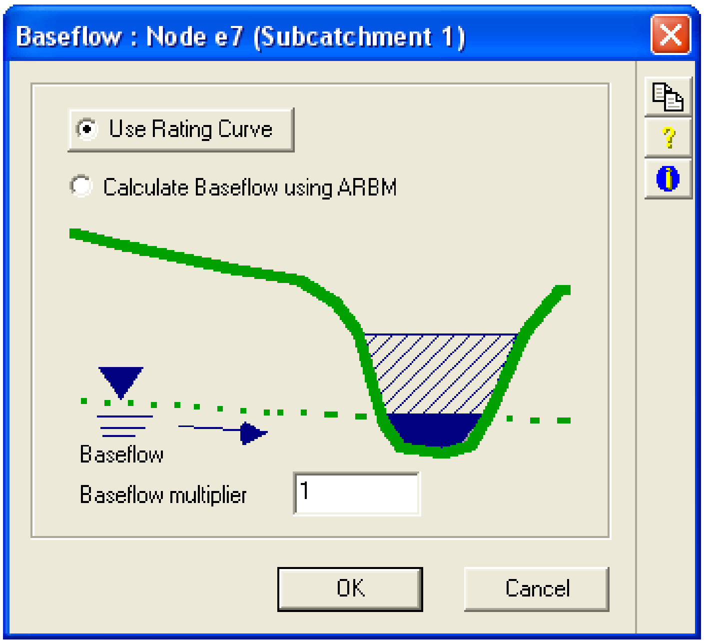
Data is reported in rows of 5 columns.

Sample	0.0420
Description	Hydrograph ordinates in m^3/s

The 2nd and 3rd rows are repeated for each tagged node. All 3 rows are repeated for each stacked storm.

Use Baseflow

This option indicates to Rafts if baseflow is to be added at this node. Baseflow can be defined for either sub-catchment portions.



Baseflow by rating curve

Use discharge/time rating curve to define part sub-catchment baseflow contribution.

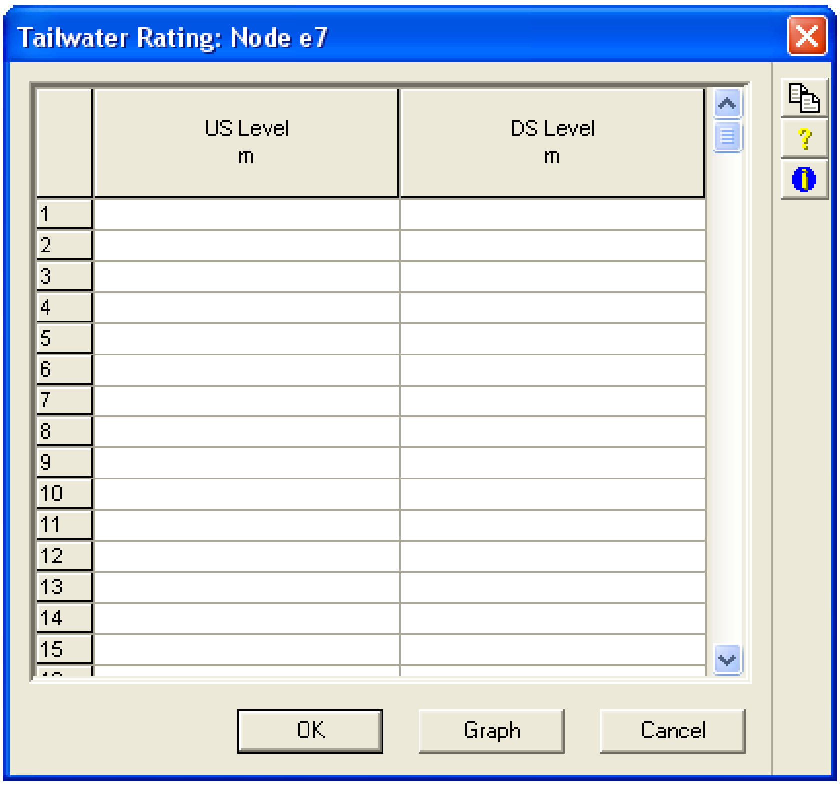
Calc Baseflow using ARBM

Flag to estimate sub-catchment portion baseflow from generated groundwater algorithms in ARBM module (see manual). This option will only be available if ARBM loss method is selected in the LRRM Hydrograph dialog.

Baseflow Multiplier

This option allows the baseflow to be scaled up or down.

Tailwater Initial Rating



Headwater Level

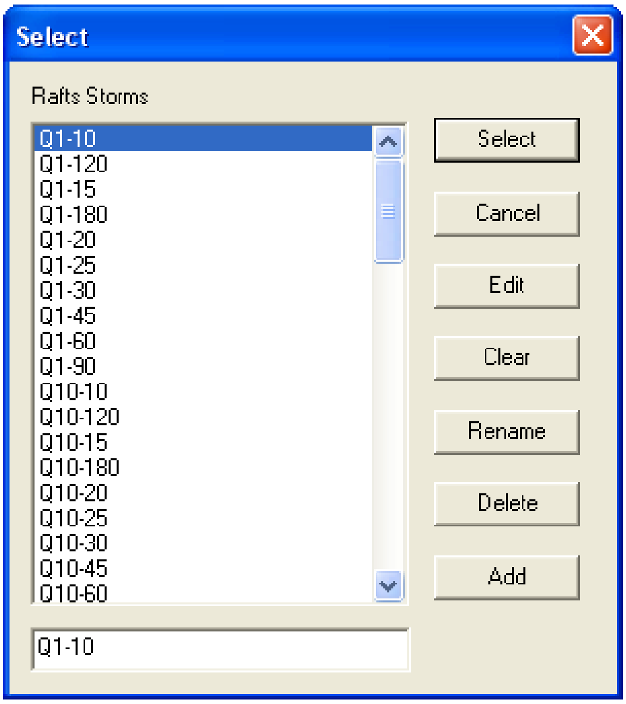
Level at conduit inlet corresponding to levels in level/discharge table. After level/discharge data is input the required levels will automatically appear in this dialog.

Values in this column are interpreted as ABSOLUTE levels if the first level equals the Basin Invert Datum Level. Otherwise, the first level MUST equal zero and values are interpreted as levels RELATIVE to the Basin Invert Datum Level.

Tailwater Level

Tailwater level immediately downstream of conduit.

Rafts Storm Name



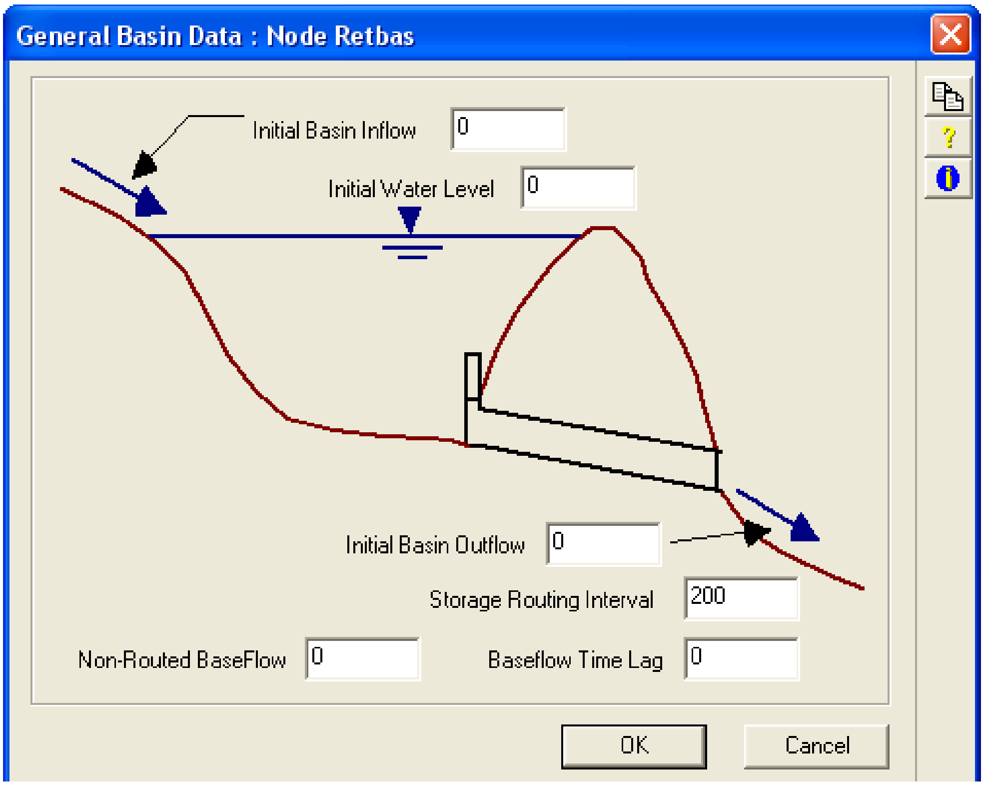
Select Rafts Storm Reference name. File usually defined in Global database definitions

Hydsys Prophet Storm Name

Select Hydsys/Prophet Storm Reference name. File usually defined in Global database definitions

Basin General Data

Includes data on Initial Basin conditions, storage routing interval, plus non-routed baseflow lag.



Initial Basin Inflow

Basin inflow (m^3/s) at start of simulation. Used only when assessing partially full basin.

Initial Water Level

Initial Basin Water Level (m) at beginning of the simulation.

Initial Basin Outflow

Initial Basin Outflow (m^3/s) at the beginning of the simulation to align with total level/discharge relationship and assumed initial water level in basin.

Storage Routing Interval

Volume routing increment (m3). The default value is 200 m3.

Consideration should be given to decreasing or increasing this volume to either maintain numerical stability in small basins or decrease computing time in bigger basins respectively.

A desirable volume routing increment should be less then 10% of expected Max. Basin Storage for numerical stability, and greater than 0.001% of the same to avoid time consuming basin routing simulations.

Non-Routed Baseflow

Non-routed baseflow under basin usually in underground conduit.

The non-routed discharge is optionally subtracted from the total inflow hydrograph to the basin so separate routing can occur. The basin outflow hydrograph is the combination of the routed surface flow plus the non-routed (but lagged) non-routed flow.

It is possible to examine the separate outflows under the full text outflow option.

Baseflow Lag Time

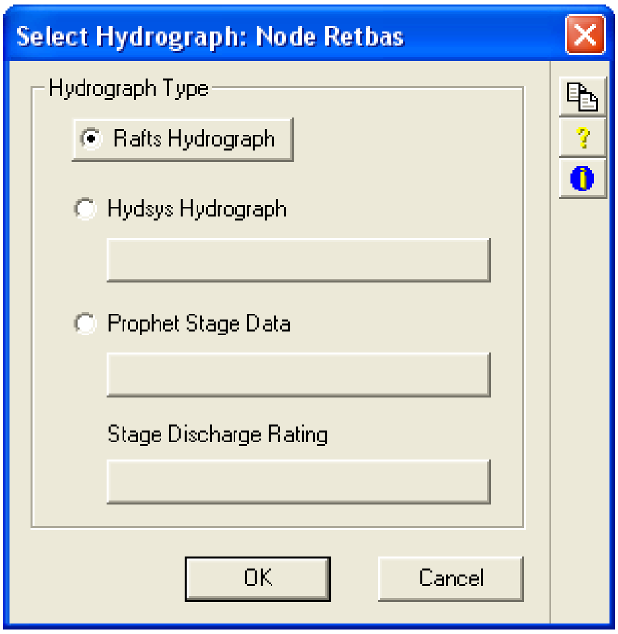
Lag time of non-routed baseflow through basin (minutes).

Gauged Hydrograph

Gauged Hydrograph

Gauged Hydrograph

A gauged hydrograph may optionally be entered for comparative display against a computed hydrograph when undertaking calibration or verification. There are four available file formats to choose from.



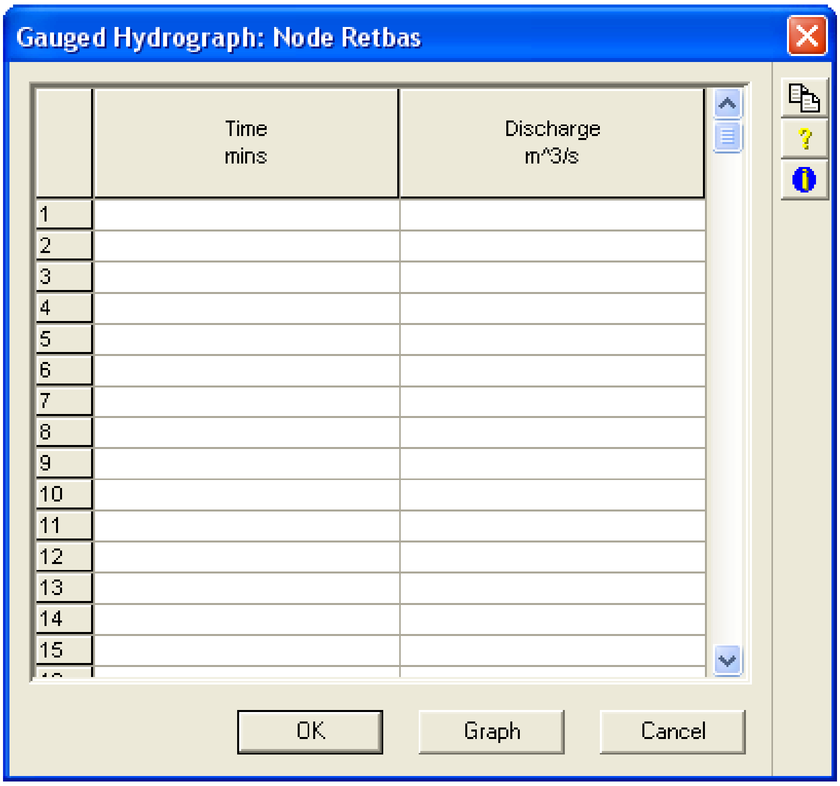
Gauged Rafts Hydrograph

Gauged Hydsys Hydrograph

Gauged Prophet Hydrograph

Gauged Stage Discharge Rating

Gauged Rafts Hydro



Time

Time from start of simulation in minutes.

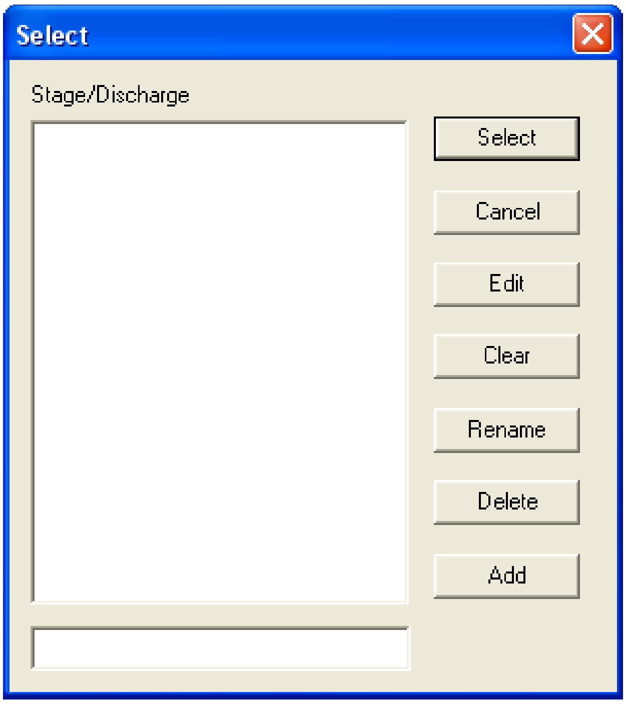
Discharge

Flow in m3/s at corresponding time.

Gauged Hyd Prophet Hydro

Select Hydsys/Prophet Reference name. File usually defined in Global database definitions.

Gauged Stage Discharge

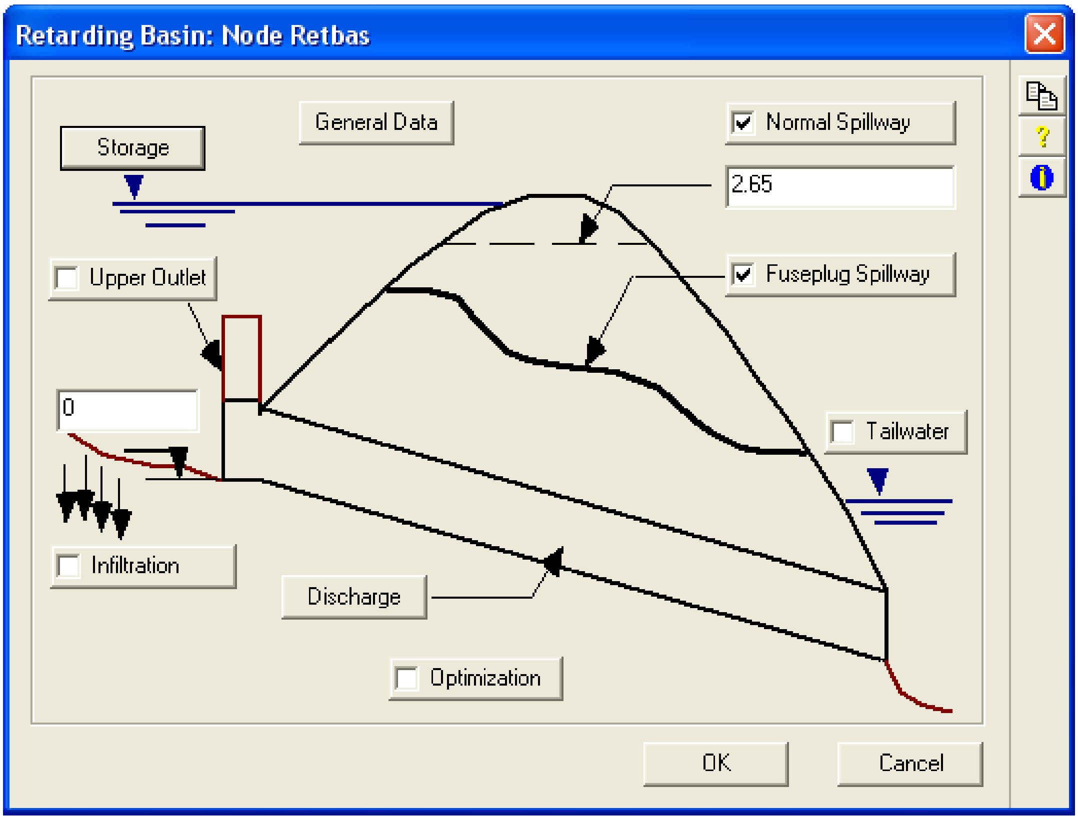


Select Gauged Stage/Discharge Reference name. File usually defined in Global database definitions.

Retarding Basin

Retarding Basin

A time of concentration must be defined for the impervious and pervious portions of the catchment separately. These may be defined in one of three ways:



Retarding Basin

All the information describing the retarding basin or on-site storage at this node is entered by entering the appropriate information behind the labelled buttons on this dialog.

Basin General Data

Basin Storage

Upper Outlet

Floor Infiltration

Outlet Optimization

Normal Spillway

Fuseplug Spillway

Basin Tailwater

Basin Invert Datum Level

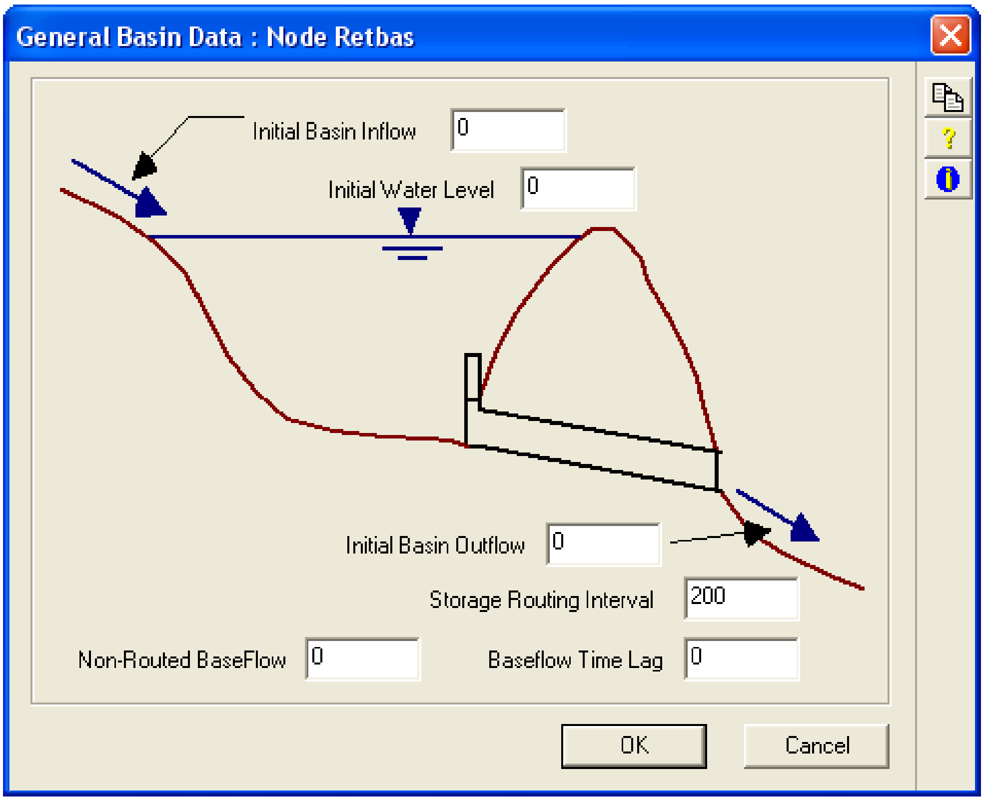
Level of outlet conduit invert at entrance. This level is used to tie ALL interconnected basins together, and is the datum level for levels in the basin level-storage, level-discharge, and level-tailwater relations.

Spillway Depth

Depth of water below the normal spillway sill, in metres. This value is only required if the Normal Spillway checkbox is on.

Basin General Data

Includes data on Initial Basin conditions, storage routing interval, plus non-routed baseflow lag.



Initial Basin Inflow

Basin inflow (m^3/s) at start of simulation. Used only when assessing partially full basin.

Initial Water Level

Initial Basin Water Level (m) at beginning of the simulation.

Initial Basin Outflow

Initial Basin Outflow (m^3/s) at the beginning of the simulation to align with total level/discharge relationship and assumed initial water level in basin.

Storage Routing Interval

Volume routing increment (m3). The default value is 200 m3.

Consideration should be given to decreasing or increasing this volume to either maintain numerical stability in small basins or decrease computing time in bigger basins respectively.

A desirable volume routing increment should be less then 10% of expected Max. Basin Storage for numerical stability, and greater than 0.001% of the same to avoid time consuming basin routing simulations.

Non-Routed Baseflow

Non-routed baseflow under basin usually in underground conduit.

The non-routed discharge is optionally subtracted from the total inflow hydrograph to the basin so separate routing can occur. The basin outflow hydrograph is the combination of the routed surface flow plus the non-routed (but lagged) non-routed flow.

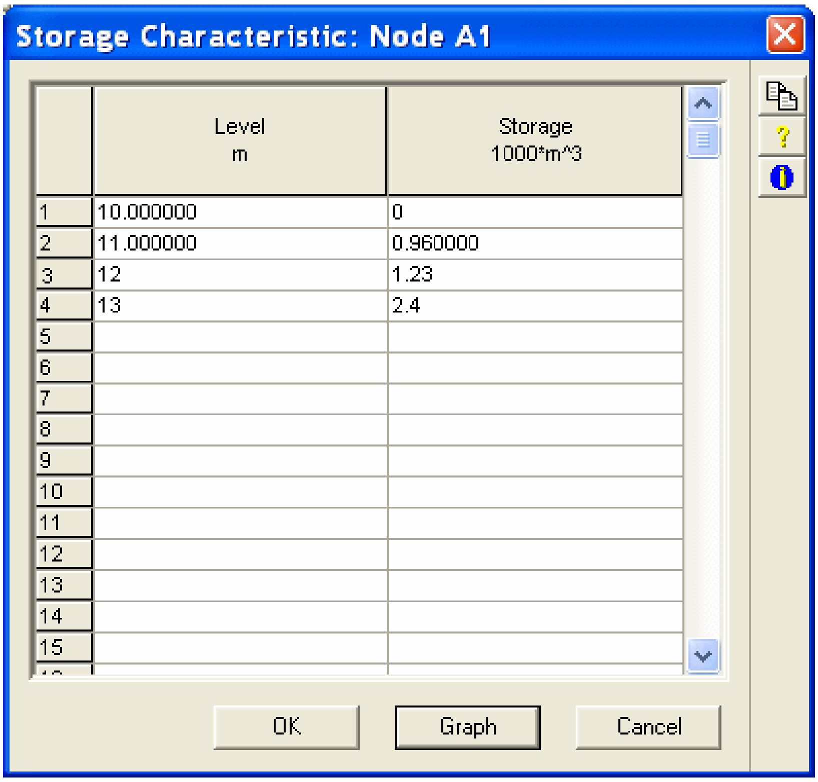
It is possible to examine the separate outflows under the full text outflow option.

Baseflow Lag Time

Lag time of non-routed baseflow through basin (minutes).

Basin Storage

Defined by basin level/storage data.



Level

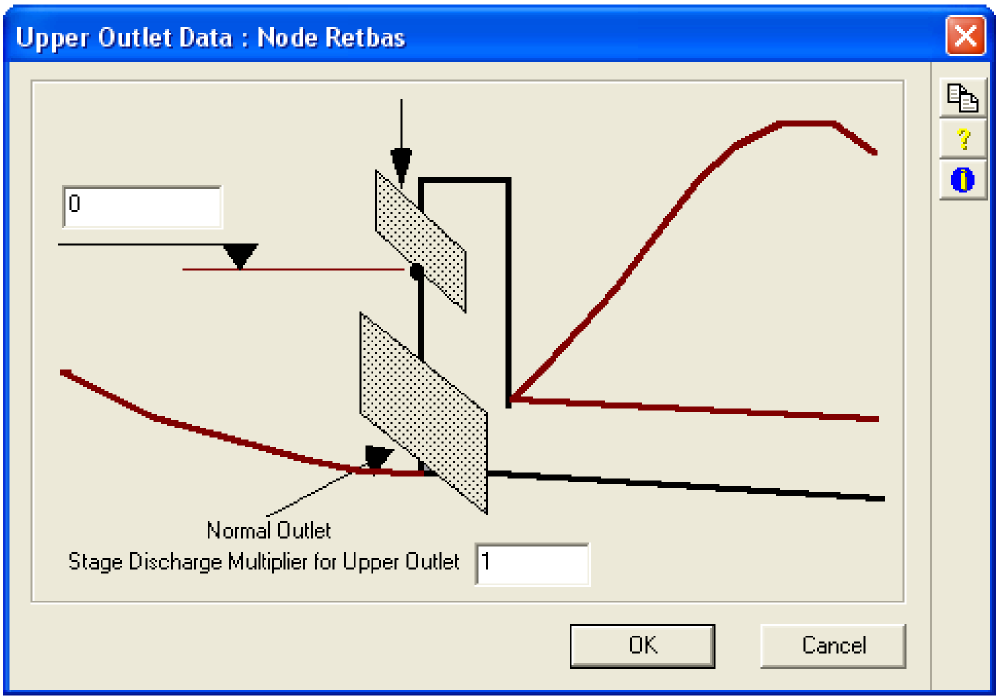
Basin Water Level (m). The first water level must also be the lowest level in the reservoir/basin.

Values in this column are interpreted as ABSOLUTE levels if the first stage equals the Basin Invert Datum Level. Otherwise, the first stage MUST equal zero and values are interpreted as stages RELATIVE to the Basin Invert Datum Level.

Storage

Storage (in 1000 cubic metres) corresponding to adjacent left column. Storages must be non-negative. The first storage MUST be zero.

Upper Outlet



Upper Outlet Data

Includes data on a orifice type outlet if required. Allows up to 2 slots in a single tower structure. Orifice type outlets presently are NOT tied to downstream interconnected basins.

Two tiered orifices are designed in two passes.

Level/discharge is defined by co-ordinates only.

The first run, often for say a 5yr storm, allows you to define the final width of the bottom orifice (PDIA) the pipe diameter variable used as a width factor and the max water level reached.

This allows the user to input the bottom width factor and the sill level for the second orifice equal to max water level. The second run, often for a 100yr storm, will then allow the user to size the upper orifice by varying PDIA while holding the lower slot dimensions.

Both orifices are assumed equal height.

Upper Outlet Invert

Level of upper outlet invert. This level is used in conjunction with two stage orifice optimisation for designing outlets for two return periods. The level should ONLY be set on the second run, equal to the maximum water level during the first run.

Discharge Factor

This factor is a multiplier to the normal outlet level-discharge relation, defining a new level-discharge relation for an upper outlet.

When designing a two level outlet, this value and the upper outlet invert are frozen on the second run.

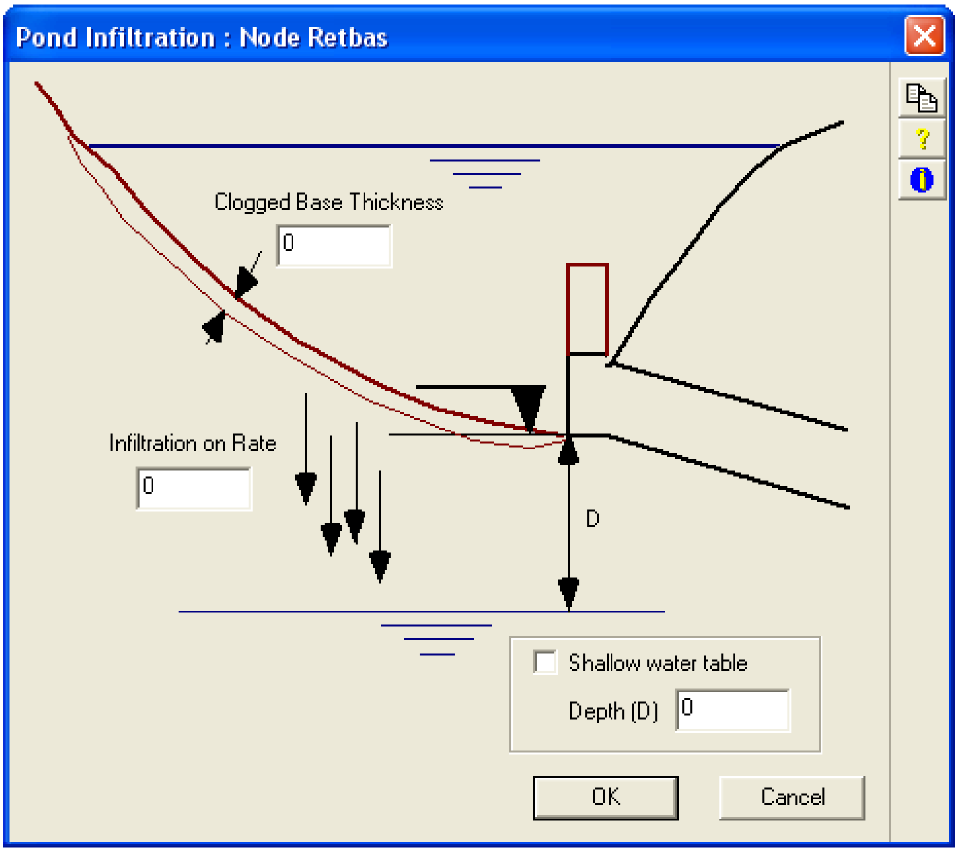
Width Factors

Includes data on a orifice type outlet if required. Allows up to 2 slots in a single tower structure. Orifice type outlets presently are NOT tied to downstream interconnected basins. Two tiered orifices are designed in two passes.

Level/discharge is defined by co-ordinates only. The first run, often for say a 5yr storm, allows you to define the final width of the bottom orifice (PDIA) the pipe diameter variable used as a width factor and the max water level reached.

This allows the user to input the bottom width factor and the sill level for the second orifice equal to max water level. The second run, often for a 100yr storm, will then allow the user to size the upper orifice by varying PDIA while holding the lower slot dimensions. Both orifices are assumed equal height.

Floor Infiltration



Pond Infiltration

RAFTS provides for leakage from basins and reservoirs in addition to evaporation losses and conventional outflow. Three strata situations are presently covered. These include a Shallow Water Table, Deep Water Table and Clogged Surface Layer. The equations utilise the work of Bouwer (1978), Bear et al (1968) and Todd (1980) to define

shallow water table situations. The methods prescribed are similar to those utilised by Main Roads (Western Australia) PC SUMP(C) software.

Basin Infiltration Rate

Discharge through basin floor infiltration expressed in m/hr. This value represents the hydraulic conductivity of the basin floor.

Clogged layer

Thickness of clogged layer in metres. The Permeability value (or infiltration rate) in m/hr should now relate to this clogged layer.

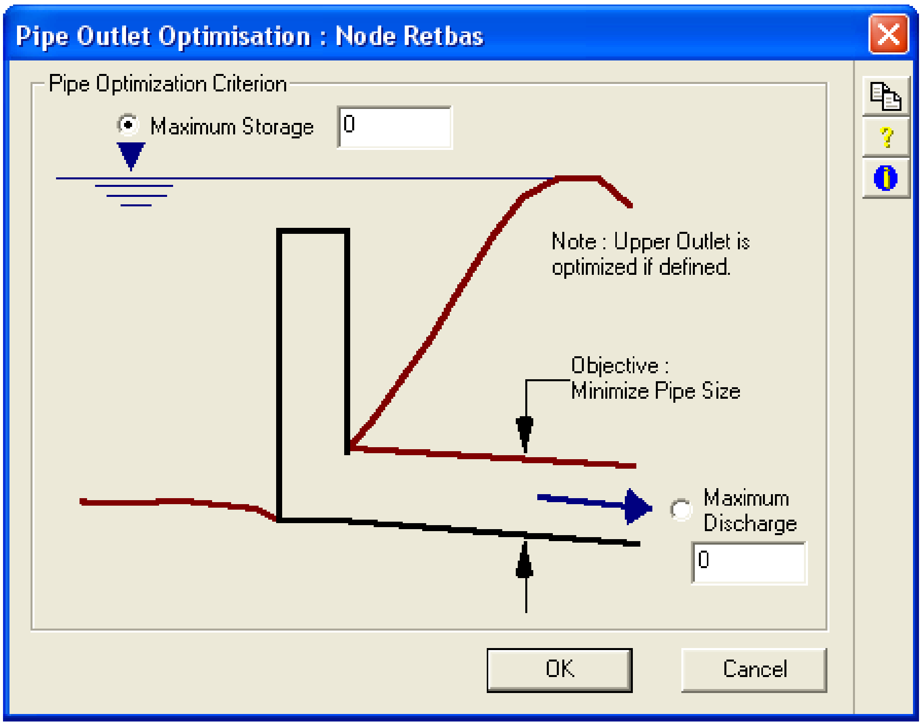
Water table

Depth of water table below the invert of the basin in metres. This option is only required if the 'Shallow water table' flag is turned ON.

Shallow Water table

Select this option to model a shallow water table at the given depth. If this flag is off then a deep water table is implied with no interaction with the infiltration flow.

Outlet Optimization



Optimisation

Contains data to either optimise the storage in the basin or to limit the discharge during the current storm event.

Pipe Outlet Optimisation

Optimisation can be performed either on the maximum storage in the basin or the maximum discharge.

Maximum Storage

Set this option ON to optimise the Outlet Pipe by maximum storage.

Maximum Discharge

Set this option ON to optimise the Outlet Pipe by maximum discharge.

Pipe Optimisation

Optimisation can be performed either on the maximum storage in the basin or the maximum discharge.

Target Storage

Maximum target storage in basin in cubic metres. This value is only required if the 'Maximum Storage' option is selected.

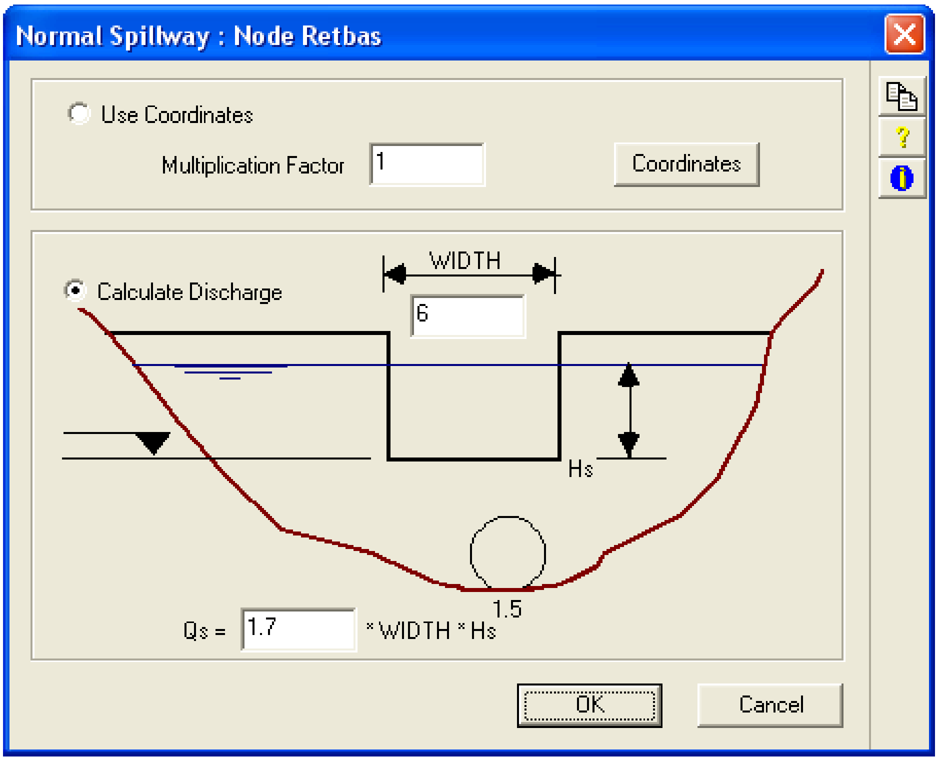
Target Discharge

Maximum target discharge from basin in cumecs. This value is only required if the 'Maximum Discharge' option is selected.

Upper Outlet

If an upper outlet is defined, then that outlet is optimised; otherwise the normal lower outlet is optimised.

Normal Spillway



Normal Spillway

Contains all data for normal, non-erodible spillway.

Spillway Length

Effective spillway length (metres). Calculated spillway flows are then added to normal outlet level/discharge co-ordinate flows.

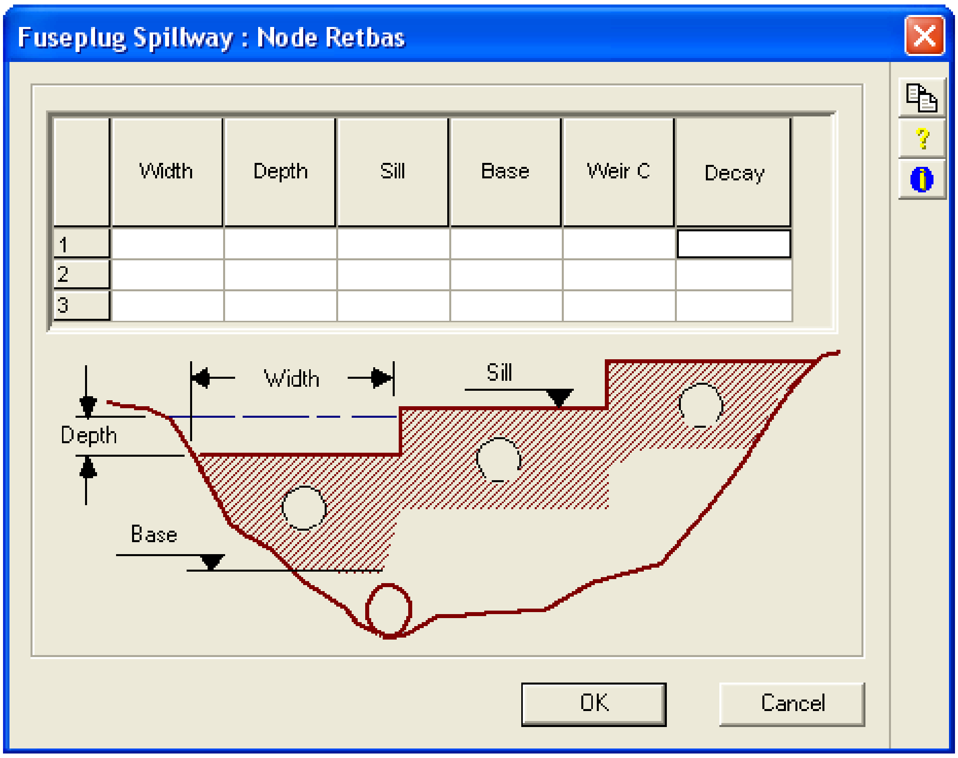
Multiplication Factor

Discharge values entered in the coordinates dialog will be multiplied by the value entered in this item.

Use Coordinates

If this option is selected Rafts expects the normal spillway to be described by way of level/discharge co-ordinates. Zero level in this case starts from the weir still level. Discharges are in m^3/s.

Fuseplug Spillway



Fuseplug Spillway

Data for an erodible spillway. Up to a 3 stage failure mode spillway system is allowed.

Fuseplug Spillway Width

Length of fuseplug spillway in metres.

Surcharge Depth

Surcharge depth to initiate failure in metres.

Sill

Level of Spillway Sill.

Base

Level of base of spillway. This level is assumed to be the final failure level.

Weir Coefficient

Weir Coefficient used in Weir equation. The default value is 1.7.

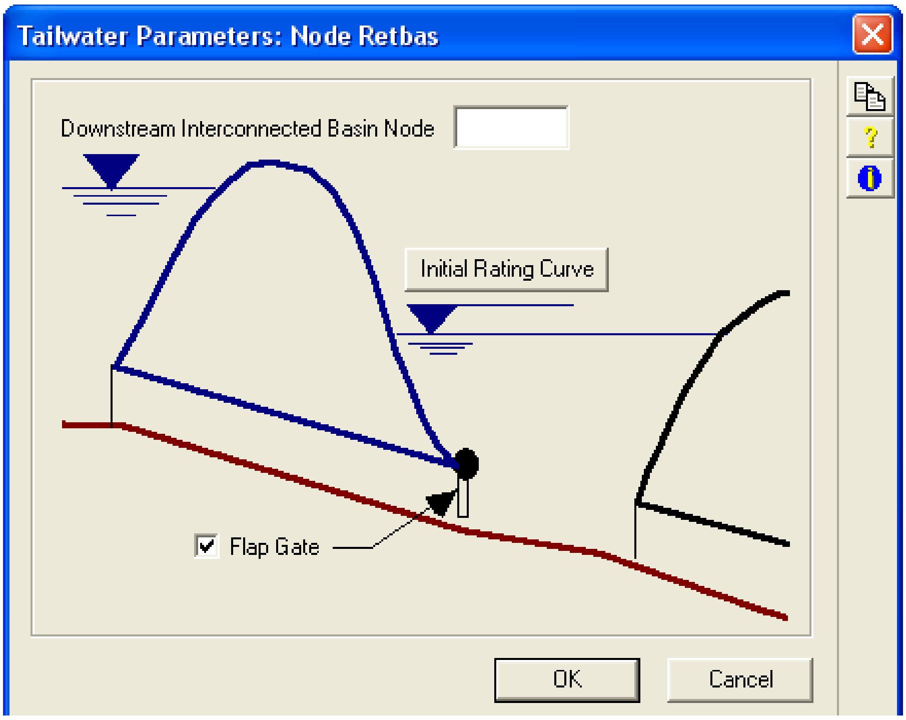
Decay Rate

Lateral decay rate of failure in m/hr. The time to fail is interpreted linearly after failure commences. Failure occurs laterally over full depth while water level above base RL.

Basin Tailwater

Tailwater

Contains data necessary when considering interconnected basins.



Tailwater Initial RatingTailwater_Initial_Rating>Main

Downstream Connected Node

Only required when the hydraulically interconnected basins option is applied.

It is the appropriate downstream node label containing the basin likely to affect the current basin outflow relationship.

Only required when the hydraulically interconnected basins option is applied.

Initial Rating Curve

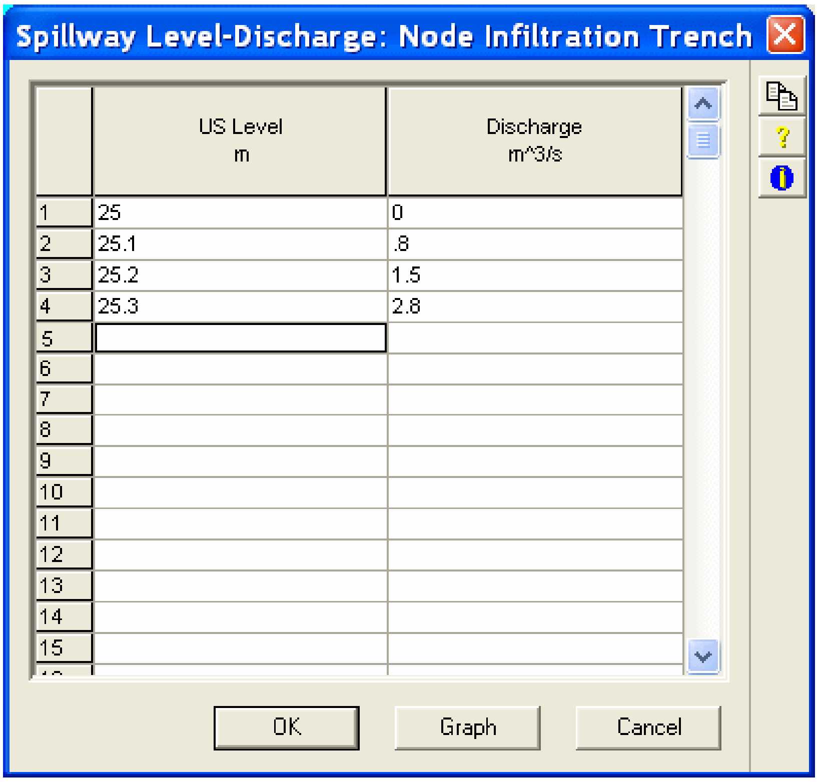
Hydraulically interconnected basin flag to indicate an initial tailwater rating curve for immediately downstream of current basin. This is only required with the level/discharge option for the normal outlet flow. It is not required if the 'Culvert Outlet' option is selected in the Discharge dialog.

Flap Gate Option

If the flap gate flag is turned on then negative flows from a downstream basin are not allowed. If the flap gate flag is not turned on then negative flows through normal outlet can occur from higher levels in downstream basins.

Flows are only assumed to occur through the normal outlet. No allowance is presently made for spillway submergence or reverse spillway flows.

Spillway Rating Curve



US Water Level

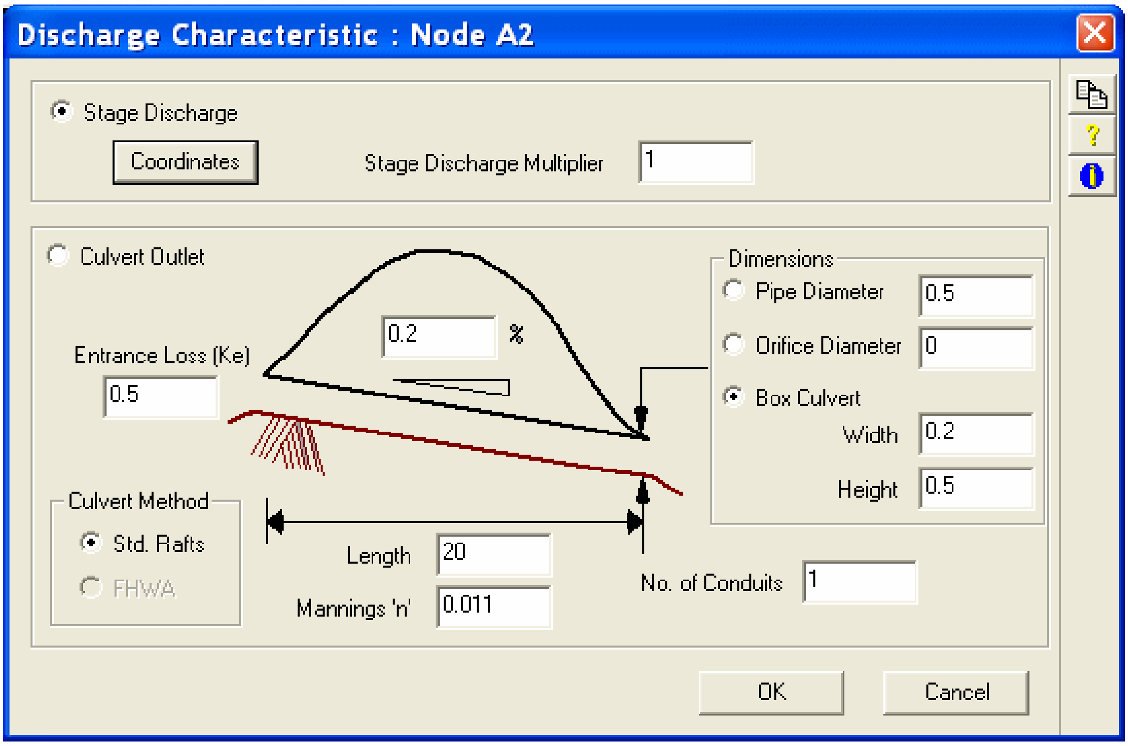
level of water surface immediately upstream of spillway.

Discharge

Discharge in m3/s over spillway corresponding to US Water Level.

Conduit Discharge

Contains data on the retarding basin outlet may consists of one or more pipes or culverts, an orifice, or a user defined stage-discharge relationship.



Stage Discharge

When this button is selected, xprafts expects level/discharge co-ordinates to define normal outflow discharge relationships. Level vs. Discharge data is only required if the 'Stage Discharge' option is selected. Click on the Coordinates button to open the data dialog.

Stage/Discharge Factor

Fractional multiplier of stage/discharge values

Conduit

When the culvert outlet radio button is selected, outflows calculated by appropriate equations.

Dimensions

Select the outlet geometry.

> **Pipe Diameter**
>
> Pipe diameter (m).
>
> **Orifice Diameter**
>
> Orifice diameter (m). Entrance loss, Slope, Length, Mannings ‘n’ and Culvert Method fields are ignored.
>
> **Box Culvert**
>
> Data required for box culverts: height (m) and width (m).

Culvert Method (Std. Rafts)

Culvert Stage/Discharge calculations carried out using traditional RAFTS equations described in manual.

Culvert Method (FHWA)

Culvert Stage/Discharge calculations carried out using FHWA methods Not available at present

Entrance loss Coefficient

Culvert entrance loss coefficient default equal to 0.5

Culvert Slope

Slope of normal outlet conduit under embankment (%).

Pipe Length

Normal outlet pipe length under embankment (m).

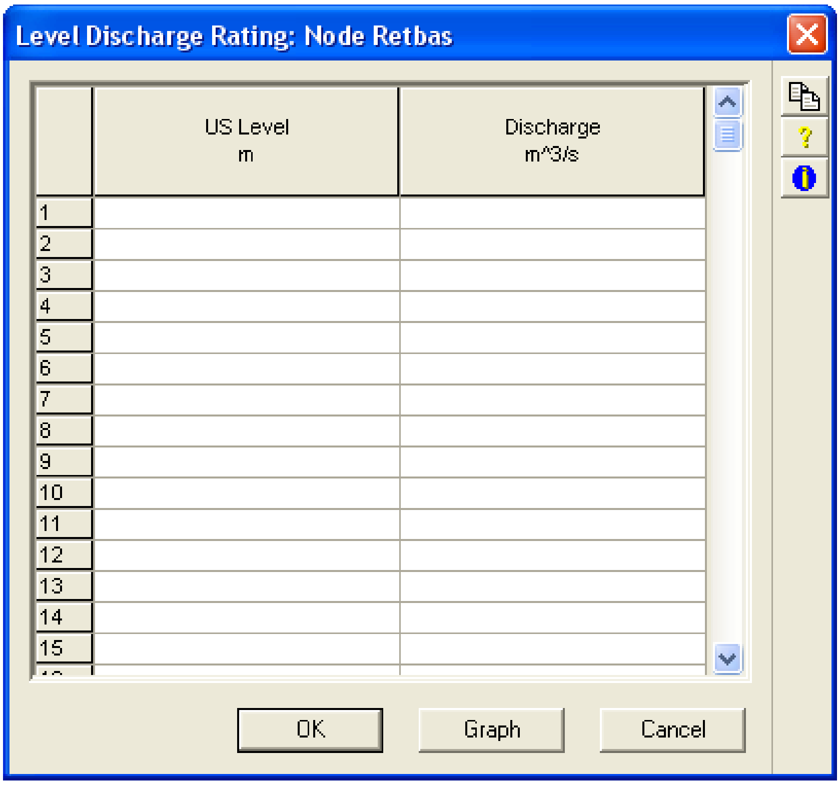
Manning's Roughness

Manning's roughness of culvert conduit.

No. of Conduits

Number of conduit barrels or orifices. All barrels are assumed equal.

Basin Stage discharge



US Water Level

Basin Water Level (m). The first water level must also be the lowest level in the reservoir/basin.

Values in this column are interpreted as ABSOLUTE levels if the first level equals the Basin Invert Datum Level. Otherwise, the first level MUST equal zero and values are interpreted as levels RELATIVE to the Basin Invert Datum Level.

Outlet Discharge

Discharge through normal conduit outlet or total discharge as defined. It is possible to use the level / discharge table to define the normal outlet discharge relationship then add a spillway discharge relationship by way of equations or rating table under spillway options. Discharges must be non-negative.

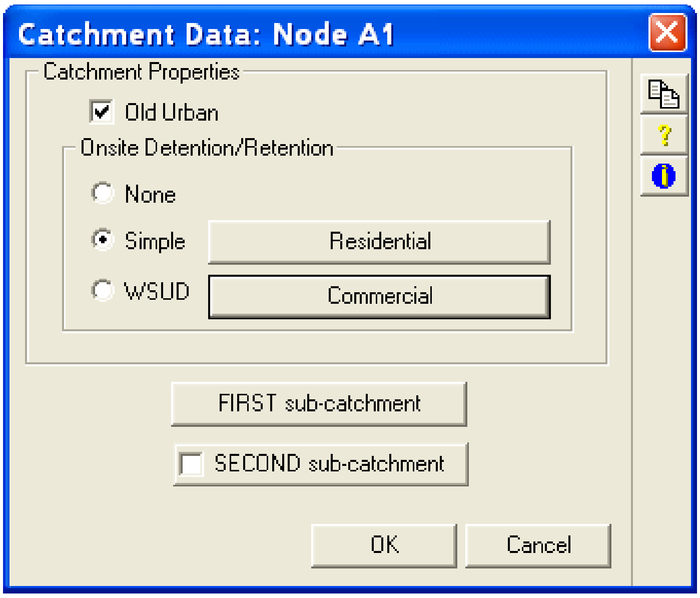
Sub-Catchment Data

SUB-CATCHMENT DATA

Laurenson's Runoff Routing Module (LRRM)

Up to two sub-areas may be defined at each node. When a sub-area is selected a local flow will be calculated using the Laurenson's runoff routing procedure. Each sub-area is treated independently and may have separately defined runoff characteristics. The sum of the local flows at the node will be added to any upstream flows to provide the total input to the top of the link or the input to a storage basin.

The second sub-area is activated by clicking in the check box adjacent to the second sub-catchment button. Data may then be entered for this sub-area. When you exit from the sub-area dialog an 'X' in the check box will indicate that this sub-area is active. If you wish to turn the sub-area off you may click in the check box to disable that sub-area. Note that none of the underlying data is lost when doing this, it is simply not used in the analysis. This data may be re-activated by clicking again in the check box.



When a sub-area is activated the following dialog is presented:

Catchment Properties

Onsite Detention/Retention

First sub-catchment

Second sub-catchment

Sub-Catchment Data

It is usual to use the first sub-catchment to determine dry weather Hydrographs and calculate either surface stormwater flows or sewage flows from both dry weather and wet weather sources.

STORMWATER MODELLING

When rural stormwater flows are being considered only it is usual to only have one (1) sub-catchment entering a node. Catchment area is input in hectares.

When urban stormwater runoff is being analysed two sub-catchments should be included to a node. These should individually reflect the pervious and impervious contributions respectively. Both catchment areas are input in hectares.

SEWER MODELLING

When sewage flows are being analysed the split catchment option should be utilised to separately estimate the dry weather and wet weather (infiltration) contributions to the node. In this instance the Catchment area for wet weather infiltration is input in hectares.

Dry weather flow catchment area is HOWEVER NOT INPUT IN HECTARES. To reflect an instantaneous diurnal dry weather flow pattern it is necessary to input as catchment area EP divided by 10,000 ie. Catchment area input = EP / 10,000.

Appropriate flow values per EP for the sub catchment together with an appropriate dimensionless diurnal temporal pattern is provided in the global storm database under Global Menu.

Sub-catchment Input

Hydrographs can calculate either surface stormwater flows or sewage flows from both dry weather and wet weather sources.

STORMWATER MODELLING

When rural stormwater flows are being considered only it is usual to only have one (1) sub-catchment entering a node. Catchment area is input in hectares.

When urban stormwater runoff is being analysed two sub-catchments should be included to a node. These should individually reflect the pervious and impervious contributions respectively. Both catchment areas are input in hectares.

SEWER MODELLING

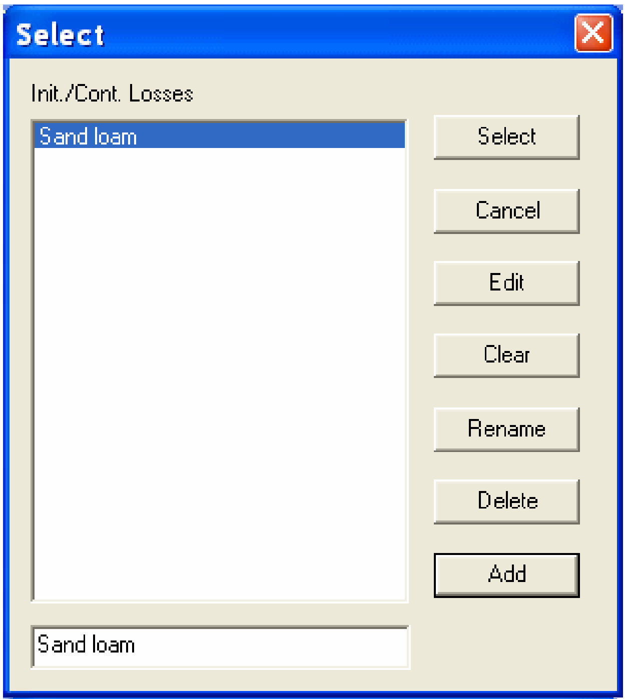
When sewage flows are being analysed the split catchment option should be utilised to separately estimate the dry weather and wet weather (infiltration) contributions to the node. In this instance the Catchment area for wet weather infiltration is input in hectares.

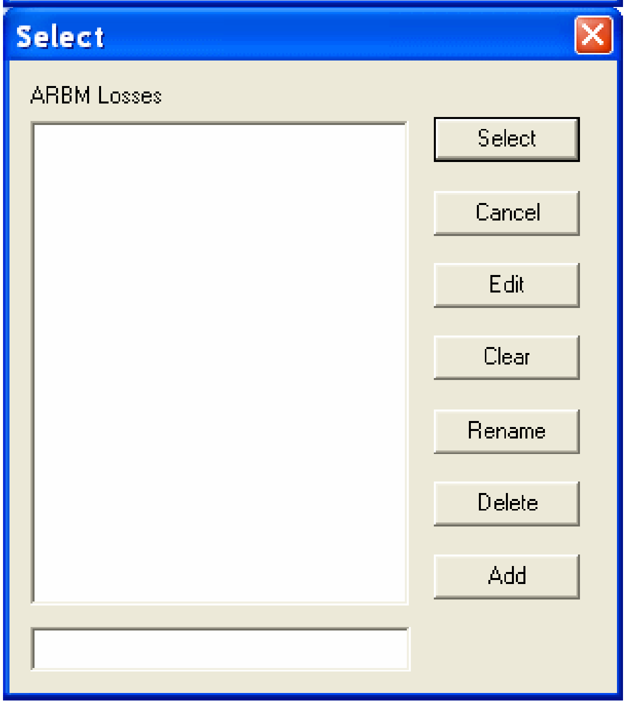
Dry weather flow catchment area is HOWEVER NOT INPUT IN HECTARES. To reflect an instantaneous diurnal dry weather flow pattern it is necessary to input as catchment area EP divided by 10,000 ie. Catchment area input = EP / 10,000

Appropriate flow values per EP for the sub catchment together with an appropriate dimensionless diurnal temporal pattern is provided in the global storm database under Global Menu.

It is usual to use the first sub-catchment to determine dry weather flow and the second sub-catchment to estimate both direct and indirect infiltration flows.

Rainfall Losses





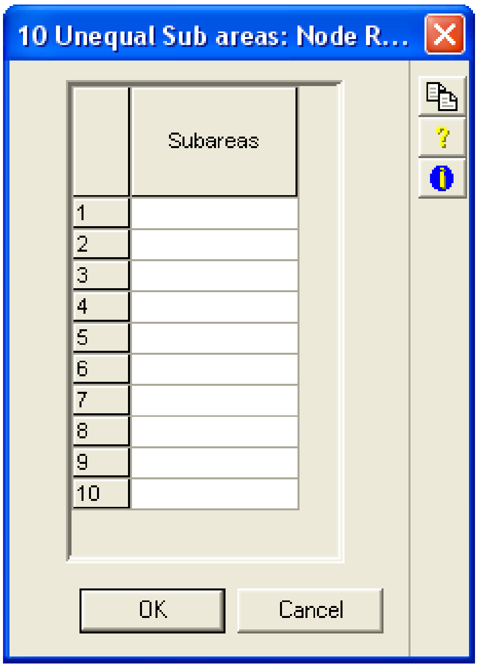
Loss Reference

A reference to the global database of ARBM losses or Initial/Continuing losses. The type of reference depends on the loss type selected in the previous dialog for the total subcatchment.

Rainfall Losses

Rainfall loss data to be applied to this portion of the sub-catchment. The values can be edited here or under the Global Data menu.

Ten unequal sub areas



Unequal Subareas

Option to select ten unequal subareas. The ten subareas must add up to the total sub-catchment area. This option is usually only used on rural sub-catchments. Urban sub-catchments unless of unusual definable shape utilise ten equal subareas for hydrograph generation.

Isochronal Areas

The ten subareas are provided as input data to the program. The procedure for computing the isochrones is based on the assumption that travel time for any element of area is proportional to:

tt μ L/S^0.5

where:

tt = travel time

L = length along a reach of the major flow path

S = average slope of the reach.

The summation is carried out for each selected point in the sub-catchment along the flow path to the outlet. Laurenson's (1964) procedure for estimating isochrones is summarised as follows:

(a) A large number of points uniformly distributed over a sub- catchment are marked on a contour map of the sub-catchment.

(b) For each point the distances between adjacent contours along the flow path to the outlet are tabulated.

(c) These individual distances are raised to the 1.5 power since time of flow through any reach is assumed proportional to:

tt μ L/S^0.5

ie tt μ L^1.5/H^0.5

where H = contour interval

Since H is constant the time of flow is proportional to L^1.5. (A correction has to be made for the lowest reach since the outlet of the catchment is not, in general, on a contour. This correction involves multiplying the length of the lowes reach by (H/H1)0.5 where H1 is the fall through the lowest reach.) The lengths to the power of 1.5 are then summed for each point.

(d) The sums obtained in (c) are divided by the greatest sum to give relative travel times for all points.

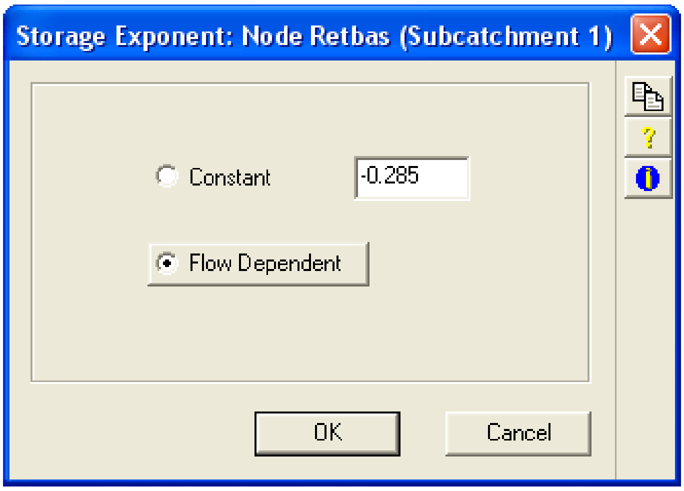
(e) Isochrones are then drawn through the points of relative travel time to give lines of equal travel times to the outlet. These are designated as the 1, 2, 3 ..... 10 isochrones. The areas between adjacent isochrones are referred to as the subareas.

It is recommended, unless very large sub-catchments are being considered, or flow paths and times through sub-catchments are particularly variable, that 10 equal subareas be considered to save data preparation. The model, in fact, provides a default for this treatment if required.

Area 1 starts at the top of the sub-catchment. Area 10 is at the bottom (at the outlet) of the sub-catchment.

Areas are in hectares. The ten areas should add up to the total sub-catchment area which is input separately.

Direct Storage Coefficient



Direct Storage Coefficient

With this option, the catchment storage coefficient is entered directly, and will override the computed coefficient from the catchment properties entered. Normally this option can be ignored, unless you wish to override the computed value with other theoretical value or for the purposes of special calibration.

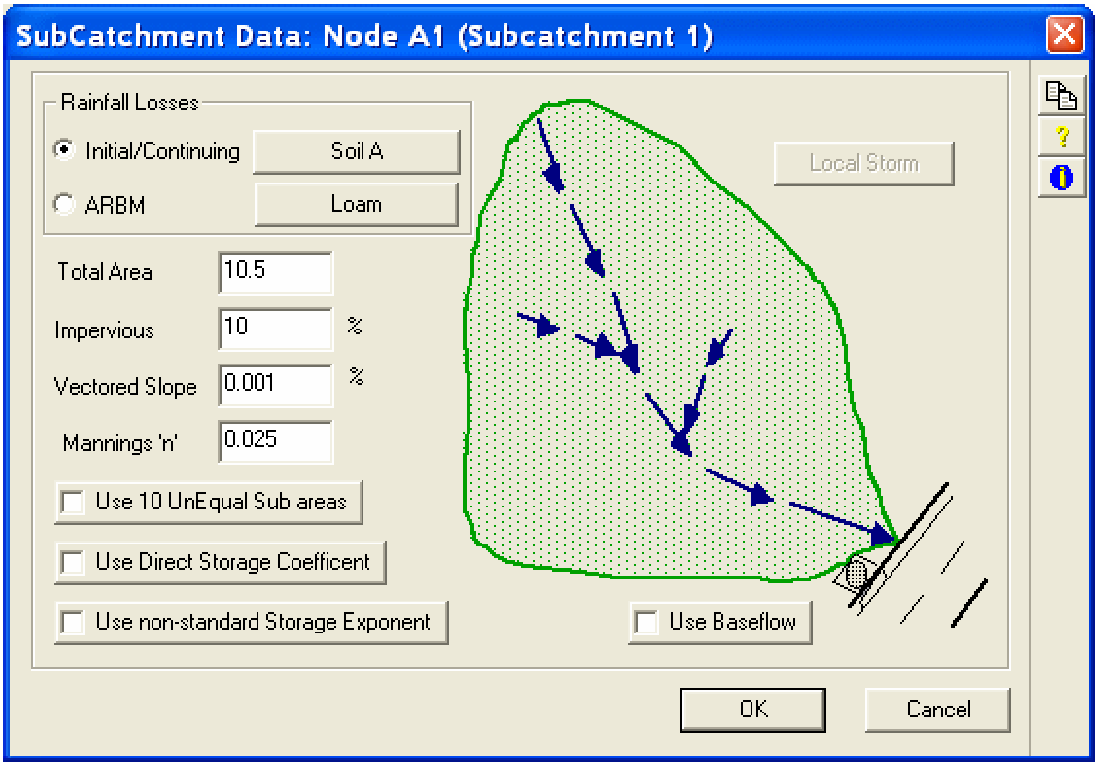
Catchment Properties

Old catchments developed for over 20 years usually lack formalised overland flow paths. When "Old Urban" is selected the storage delay factor "B" is modified depending on the Return Period event being analysed to reflect extra sub-catchment storage.

Return Period	Multiplication Factor
1	1.30
3	1.15
5	1.00
10	1.10
20	1.35
50	1.50
100	2.00

If old urban option not selected then B remains unmodified.

First sub-catchment



Rainfall Losses

Ten unequal sub areas

Direct Storage Coefficient

Non Std Storage Exponent

Local Storm Name

Use Baseflow

First Sub-catchment

It is usual to use the first sub-catchment to determine dry weather Hydrographs and calculate either surface stormwater flows or sewage flows from both dry weather and wet weather sources.

STORMWATER MODELLING

When rural stormwater flows are being considered only it is usual to only have one (1) sub-catchment entering a node. Catchment area is input in hectares.

When urban stormwater runoff is being analysed two sub-catchments should be included to a node. These should individually reflect the pervious and impervious contributions respectively. Both catchment areas are input in hectares.

SEWER MODELLING

When sewage flows are being analysed the split catchment option should be utilised to separately estimate the dry weather and wet weather (infiltration) contributions to the node. In this instance the Catchment area for wet weather infiltration is input in hectares.

Dry weather flow catchment area is HOWEVER NOT INPUT IN HECTARES. To reflect an instantaneous diurnal dry weather flow pattern it is necessary to input as catchment area EP divided by 10,000 ie. Catchment area input = EP / 10,000

Appropriate flow values per EP for the sub catchment together with an appropriate dimensionless diurnal temporal pattern is provided in the global storm database under Global Menu.

Non std storage exponent

Non-standard Storage Exponent

With this option, the catchment storage exponent is entered directly or as a function of runoff, and will override the default value.

Normally this option can be ignored. It may be applicable on large river basins during extreme events. You could use this option, for example, to define a linear relationship between catcment storage and runoff, or to develop variations to the standard storage equation to match gauged results.

Routing Exponent

Storage Routing Exponent value. This exponent defines the non- linearity of the catchments response. The default is (-0.285). A value of (-0.001) will make the catchment response linear and act similarly to a unit hydrograph approach. At present a value of zero is not acceptable to the program. The default value is usually appropriate for inbank flows with the SRE moving towards -0.001 when large floodplain overflows occur. This means more frequent storm events say below 100yr return period can usually use the default value.

Values MUST be non-zero.

Three methods are presently available for the definition of this exponent.

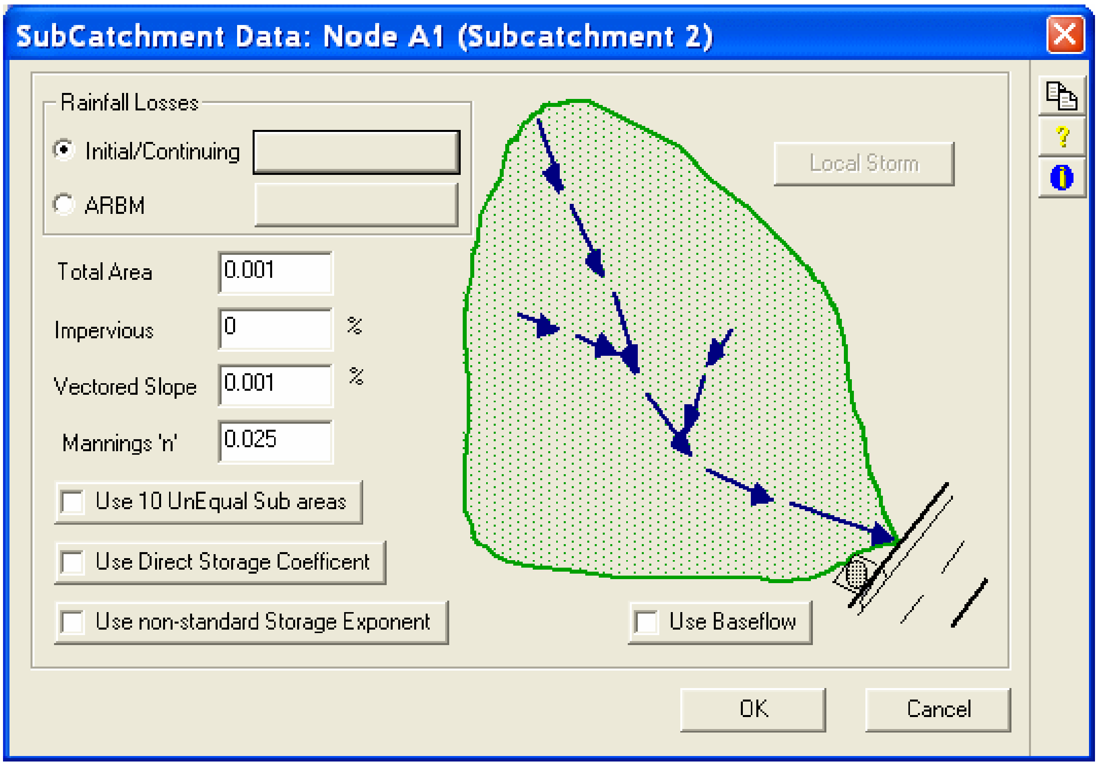
1. Use default value of -0.285.
2. Enter a constant value of your choice.
3. Enter a rating curve relating SRE to sub-catchment flow.

Rainfall Loss Method

Rainfall Loss Method

This option allows the selection of either ARBM Infiltration equations or an initial/continuing loss rate approach to estimating sub-catchment excess rainfall. The method chosen applies to both the first and optional second sub-catchments.

Second sub-catchment



Rainfall Losses

Ten unequal sub areas

Direct Storage Coefficient

Non Std Storage Exponent

Local Storm Name

Use Baseflow

Second Sub-catchment

Hydrographs can calculate either surface stormwater flows or sewage flows from both dry weather and wet weather sources.

STORMWATER MODELLING

When rural stormwater flows are being considered only it is usual to only have one (1) sub-catchment entering a node. Catchment area is input in hectares.

When urban stormwater runoff is being analysed two sub-catchments should be included to a node. These should individually reflect the pervious and impervious contributions respectively. Both catchment areas are input in hectares.

SEWER MODELLING

When sewage flows are being analysed the split catchment option should be utilised to separately estimate the dry weather and wet weather (infiltration) contributions to the node. In this instance the Catchment area for wet weather infiltration is input in hectares.

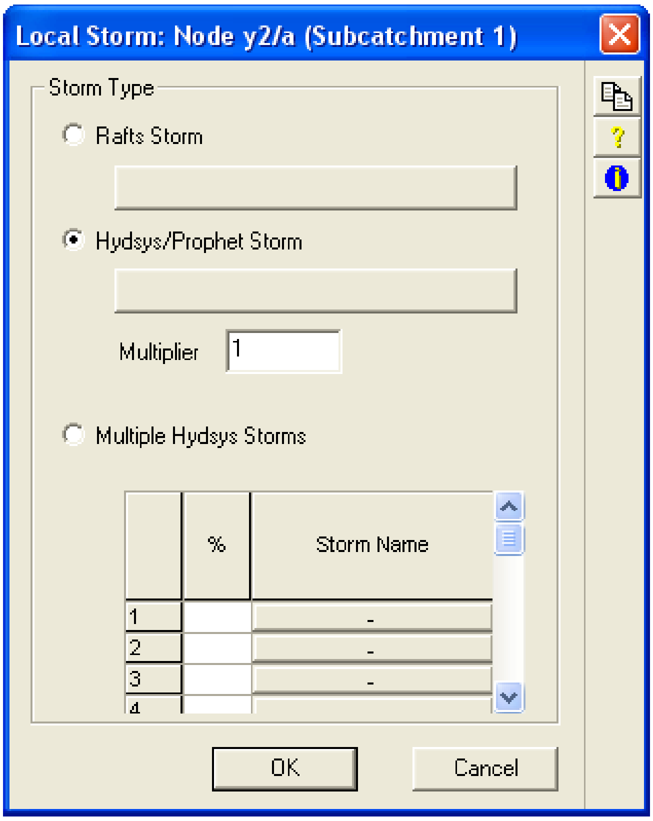
Dry weather flow catchment area is HOWEVER NOT INPUT IN HECTARES. To reflect an instantaneous diurnal dry weather flow pattern it is necessary to input as catchment area EP divided by 10,000 ie. Catchment area input = EP / 10,000

Appropriate flow values per EP for the sub catchment together with an appropriate dimensionless diurnal temporal pattern is provided in the global storm database under Global Menu.

Local Storm Name

Local Storm Reference

This allows the entry of storm data local to this sub-catchment. This button will not be available if the 'Global Storm' option has been selected in Job Control.



Rafts Storm Reference

This button allows you to select from or edit a list of Rafts Storms, which have been set up in the Global Database.

Hydsys/Prophet Storm Reference

This button allows you to select from or edit a list of Hydsys Storms, which have been set up in the Global Database.

Hydsys/Prophet Storm Multiplier

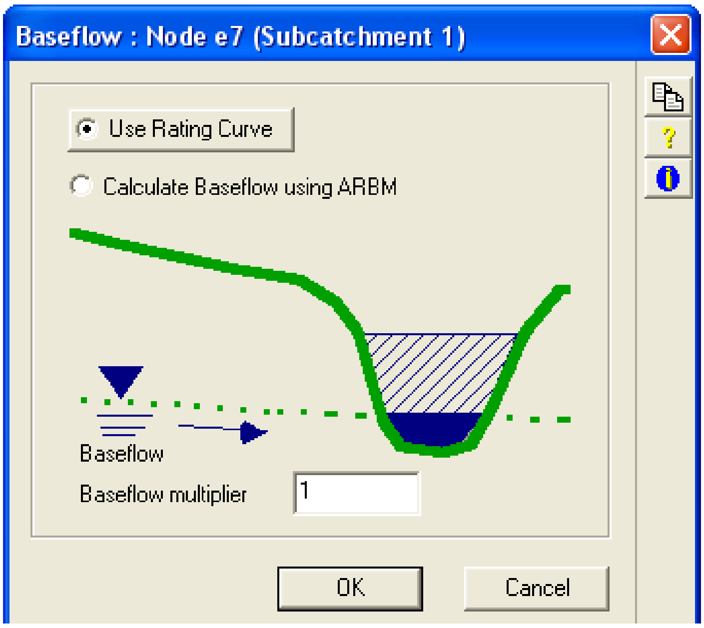
This factor is applied to all Hydsys/Prophet storm entries and is used to vary the average intensity of the storm without having to alter each entry.

Storm Type

One of two types of storm may be selected here. If a Rafts Storm is selected, the storm data comes from a design storm or an Historical storm, depending on which has been selected in the Global Database.   If an Hydsys/Prophet storm is chosen, the data comes from a file chosen in the Hydsys/Prophet Storm Global Database.

Use Baseflow

This option indicates to Rafts if baseflow is to be added at this node. Baseflow can be defined for either sub-catchment portions.



Baseflow by rating curve

Use discharge/time rating curve to define part sub-catchment baseflow contribution.

Calc Baseflow using ARBM

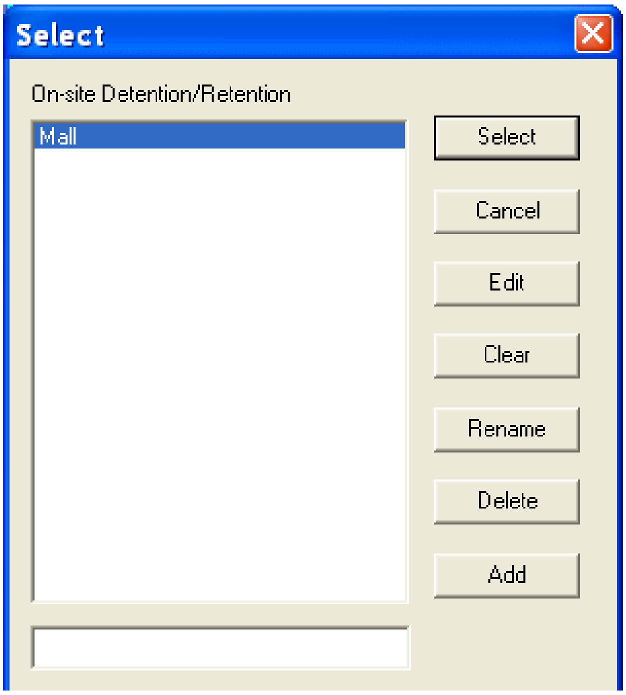
Flag to estimate sub-catchment portion baseflow from generated groundwater algorithms in ARBM module (see manual). This option will only be available if ARBM loss method is selected in the LRRM Hydrograph dialog.

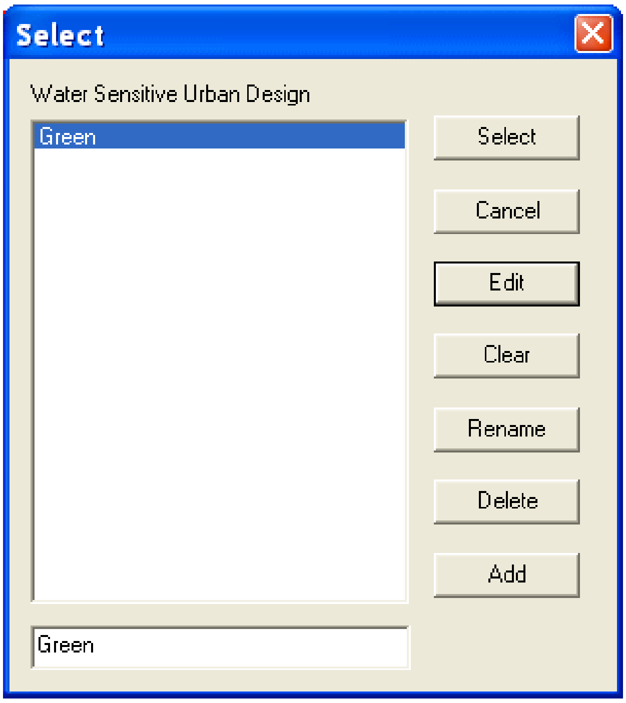
Baseflow Multiplier

This option allows the baseflow to be scaled up or down.

Simple On-site Detention/Retention

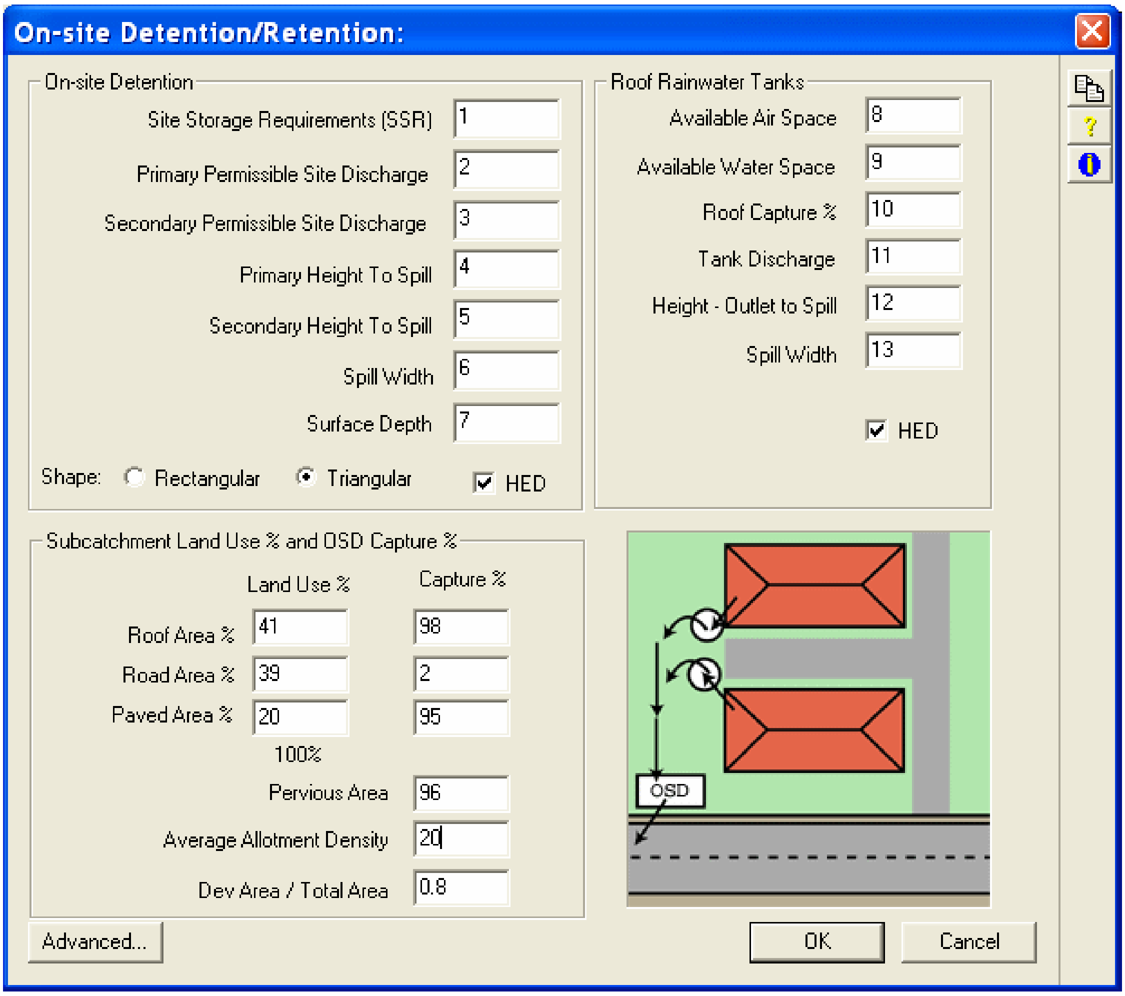
Onsite Detention/Retention



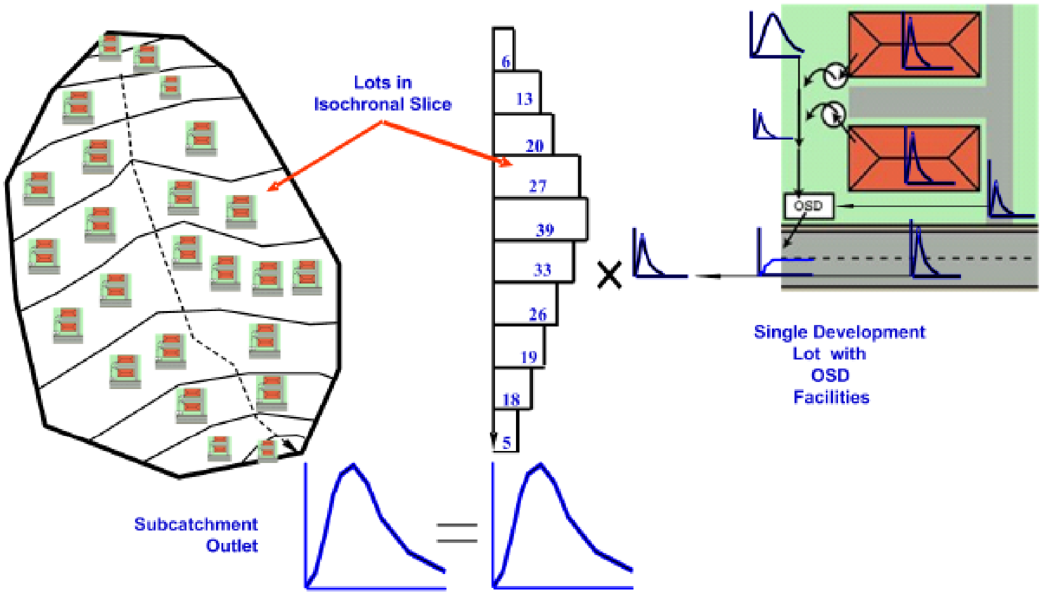


Use one of these dialogs to manage a Onsite Detention/Retention Global Database record for the Simple or Water Sensitive Urban Design procedure.

Onsite Detention/Retention - Dialog



Data for rainwater tanks when used as an OSD device are required on a per lot basis. The accumulative water tank affect on the total sub-catchment discharge is derived by multiplying the single allotment device/s by the total sub-catchment area × the dev Area/Total Area ratio × the Average Allotment Density.



Descriptions of the field contents are given in the table below.

Onsite detention	**Roof Rainwater Tanks**
Site Storage Requirements	Available Air Space
Primary Permissible Site Discharge	Available Water Space
Secondary Permissible Site Discharge	Roof Capture
Primary Height to Spill	Tank Discharge
Secondary Height to Spill	Height - Outlet to Spill
Spill Width	Spill Width
Shape HED	HED
Subcatchment Land Use % and OSD Capture %	
Previous Area	
Average Allotment Density	
Dev Area/Total Area	

Advanced

Onsite Detention/Retention - General

Detention/Retention Storage Classification

Typical OSD Storage Facilities

Site Storage Requirements

SSR is the Maximum storage of On-Site Detention Unit defined in m³/HA of developed area.

It is common for an Authority to nominate a minimum SSR requirement for an on-site detention unit within an individual allotment development. xprafts can therefore simulate an individual allotment with a node at the outlet point of every allotment or simulate the accumulative effects of a number of allotments within a single xprafts sub-catchment. The developed portion of the sub-catchment is the area enclosing all allotments that contain individual on-site units. For example if the sub-catchment contains parkland that will not include a on-site detention unit then the developed portion of the sub-catchment will be less than the total sub-catchment. The SSR dictated by an authority will be in m3/ha and will only relate to the area of the allotment itself.

Primary Permissible Site Discharge

(PSD) is the maximum Primary Permissible Site Discharge of the On-Site Detention Unit defined in l/s/ha of developed area. The outlet is usually at the invert of the unit.

Secondary Permissible Site Discharge

This is the maximum permissible discharge for an optional second discharge point from an On-Site Detention Unit at a higher elevation within the unit's outlet orifices. The reason for an optional second higher outlet point with different diameter is to allow the optimizing of units to meet down stream maximum peak flow requirements for two different flow frequencies. For example the 5year return period for piping requirements with only the lower outlet operating and then the 100 year flood flow requirements with both primary and secondary outlets operating. Note by running simulations to limit the 5 year flow peak downstream to the pre-developed level it is possible by iteration to determine appropriate SSR and primary PSD. These runs will also provide the maximum water level in the detention unit. This level will then be used to set the height of the secondary outlet whereby its size can be adjusted to meet downstream maximum peak requirements in the 100 year return period event. Note it will be necessary to run a range of ARR storm durations to locate the one that produces the maximum water level in the detention unit.

Primary Height to Spill

This height is a vertical measure in (m) between invert of the OSD's lower outlet and the invert of the secondary upper orifice outlet (OWHT).

Secondary Height to Spill

This height is a vertical measure in (m) between the lower outlet invert and the spill level of the OSD spillway (

This is a flag to indicate if a high early discharge (HED) pit is in operation. If it is then the maximum discharge rate is reached almost immediately after a relatively small volume inlet pit is filled prior to water discharging into the main OSD. If no HED is utilized the discharge rate for the outlet/s is progressively increased to the Permissible Site Discharge (PSD) at a stage equal to the Primary Height to Spill (LWHT). This will be equal to the invert of the secondary upper outlet if there is one.

Spill Width

Width of spillway (m).

Surface Depth

Distance lower orifice invert to bottom of pit (m).

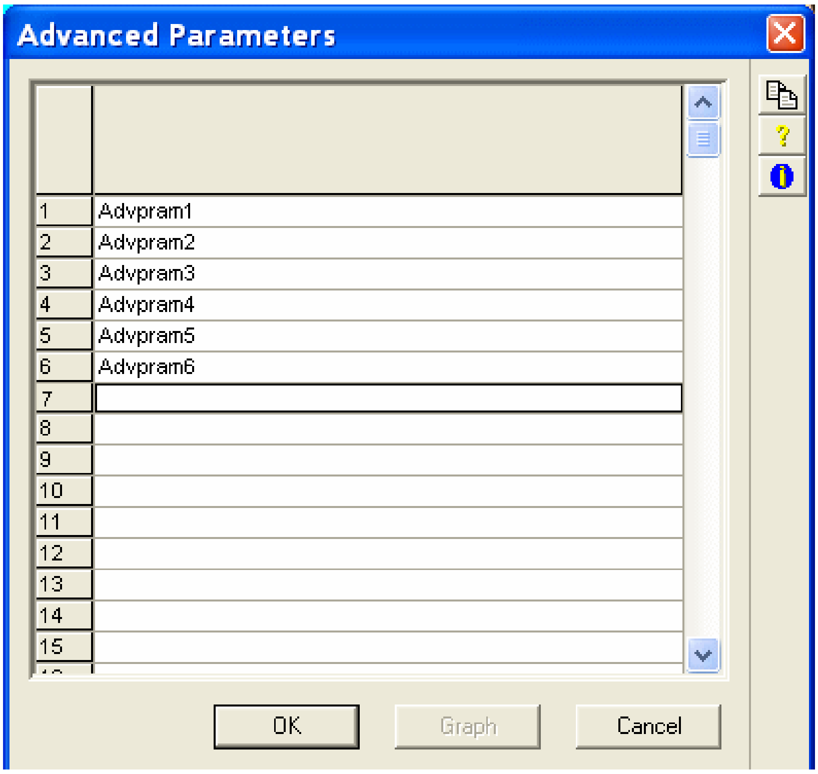
Shape

Select the appropriate shape.

HED

Check if the outlet orifice can be controlled by a high early discharge.

Advanced Parameters



There are currently six advanced options available for use with the OSD module. Each value entered on appropriate line (1-6) top to bottom.

Advpram1

If set to (1) then the upper orifice outlet will be set at the base level along side the lower (primary) outlet. The upper (secondary) outlet will be within a glory hole type vertical pit so entry will occur around perimeter of pit top opening. At a stage equal to OWHT. The primary outlet will discharge proportional to driving head while the secondary outlet will commence discharging at full FOSDSPSD during stages above OWHT as if it is operating with HED.

If Advpram1 set to (0) (the default) then the upper orifice will be assumed to be positioned normally (OWHT) above the OSD base. In this case the lower orifice and upper orifice will discharge proportionally to the driving head above each.

Advpram2

OSD depth at start of simulation as percentage and relates to O2WHT.

Advpram3

This is the assumed water depth in the water storage portion of the water tank at the commencement of a simulation run.   The value is expressed as a percentage of the total water storage portion.

Advpram4

Advprams 4, 5 and 6 are the parameters associated with the base infiltration component of the normal RAFTS retarding basin discharge.

This parameter is the infiltration rate (m/hr). (hcon)

Advpram5

This parameter is the clogged base thickness (m). (clog)

Advpram6

This parameter is the shallow water table depth (m). (wtdep)

Roof Rainwater Tanks

Available Air Space

The available air space is the volume of allotment tank space between the orifice outlet and the spillway sill. (m^3/lot).

Available Water Space

The available water space is the volume of allotment tank space below the orifice outlet invert (m^3/lot).

Roof Capture

This represents the percentage of allotment roof area directed into the watertank (%).

Tank Discharge

This is the discharge from the orifice in the side of the water tank with a driving head equal to TWHT (m).

Height Outlet to Spill

This is the height between the invert of the orifice outlet and the sill of the spillway at the top of the tank (m).

Spill Width

This is the spillway width represented in terms of metres per area of sub-catchment x development ratio (m/HA).

HED

Check if the outlet orifice can be controlled by a high early discharge.

Subcatchment Land Use

Subcatchment Land Use

Land Use %

The subarea breakup of the sub-catchment is described in the adjacent dialogs in terms of firstly the pervious area and in the second dialog the total impervious area.

The following roof, road and paved area percentages provide a description of the further breakup of the impervious surfaces within the sub-catchment.

Roof Area %

Road Area %

Paved Area %

The three component percentages should added up to 100%

Capture %

The % capture values for each impervious component area is the % that enters the OSD/s.

Pervious Area

Similarly the % of the pervious area component that enters the OSD/s is also required.

Average Allotment Density

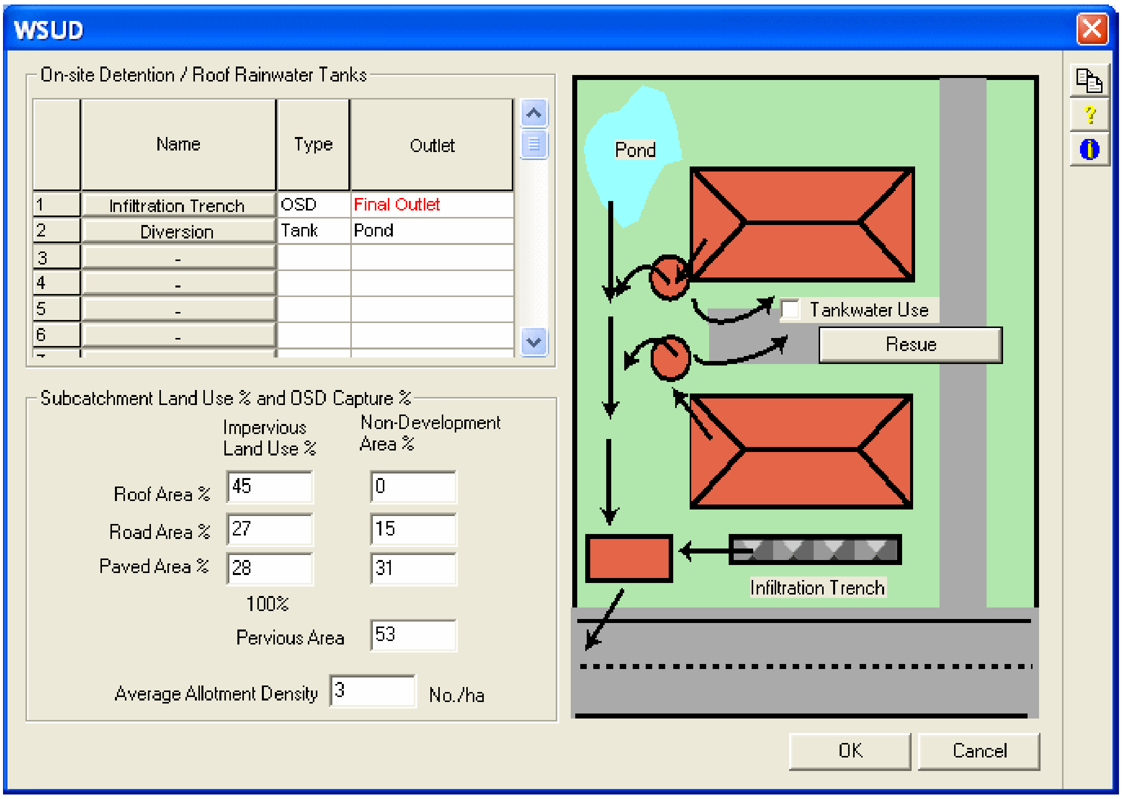
The average allotment density in (number of lots per ha) is required mainly for the rainwater tank component of any OSD systems.

Dev Area Ratio

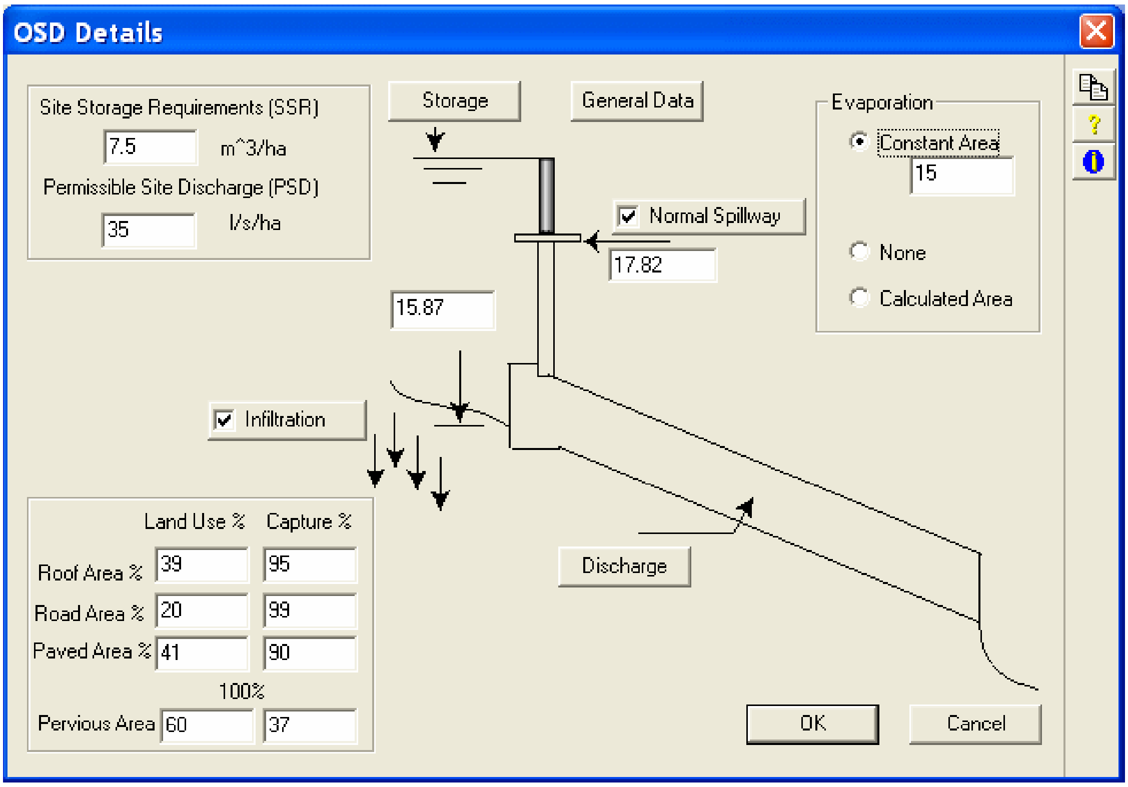
This ratio describes the area of controllable private land by OSD over the total sub-catchment area. For example if the total sub-catchment contains a large urban residential component that requires OSD control, however also contains say 20% of parkland and public road that is not controlled by OSD then the Dev Area/Total Area ratio would be 0.8

WSUD Onsite Detention/Retention

Water Sensitive Urban Design



OSD Details



Site Storage Requirement

Permissible Site Discharge

Storage

General Data

Normal Spillway

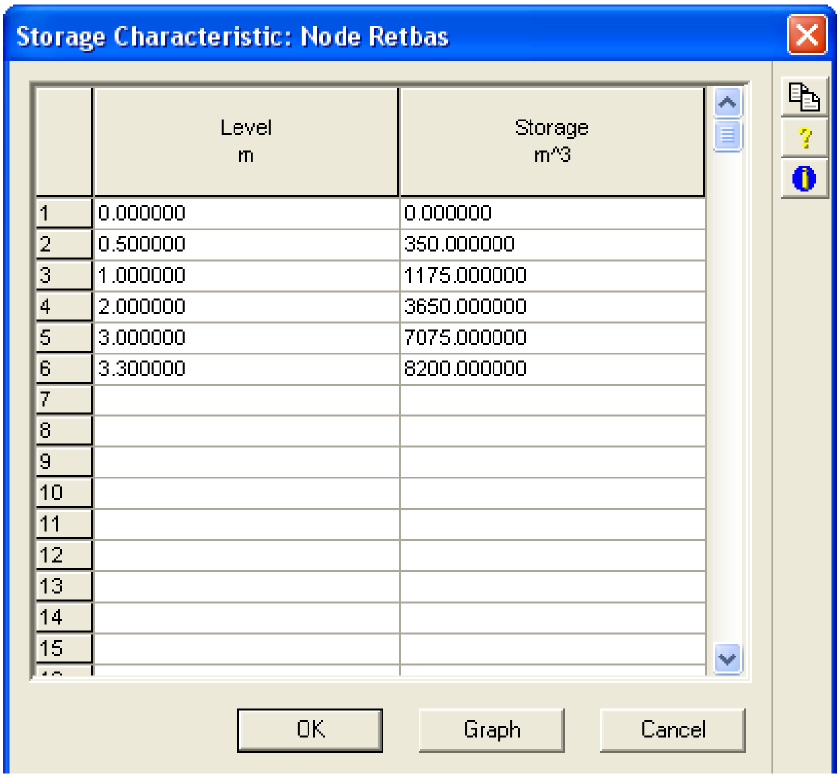
Evaporation

Infiltration

Discharge

Landuse%

Storage



Level

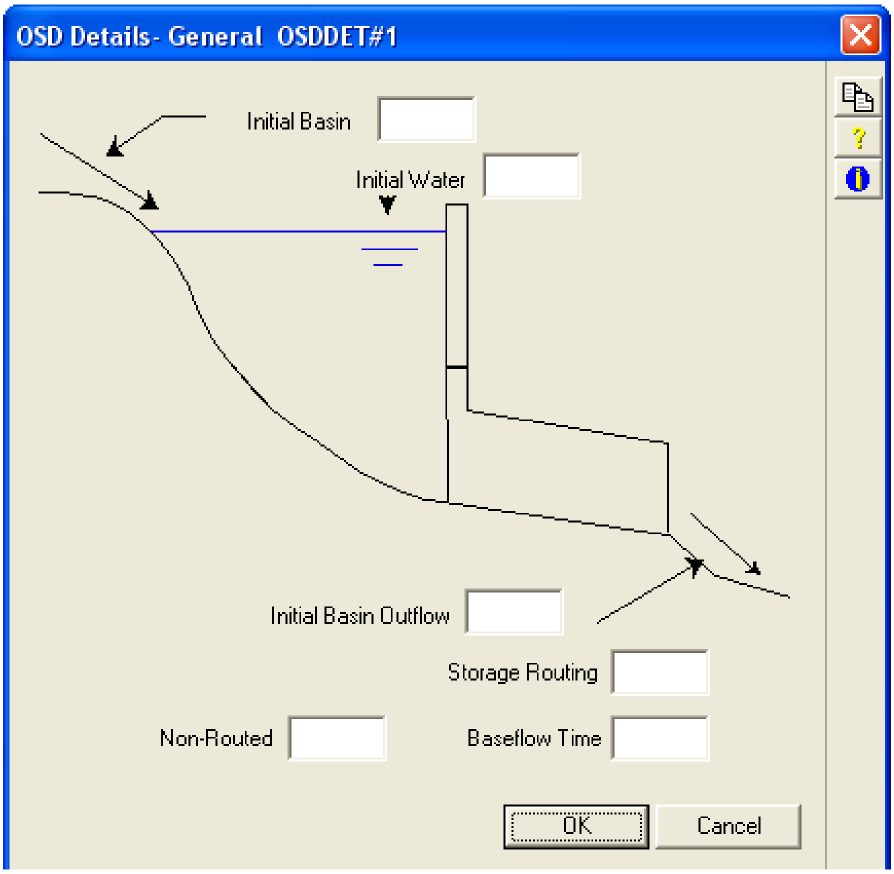
Basin Water Level (m). The first water level must also be the lowest level in the reservoir/basin.

Values in this column are interpreted as ABSOLUTE levels if the first stage equals the Basin Invert Datum Level. Otherwise, the first stage MUST equal zero and values are interpreted as stages RELATIVE to the Basin Invert Datum Level.

Storage

Storage (in 1000 cubic metres) corresponding to adjacent left column. Storages must be non-negative. The first storage MUST be zero.

General Data



Initial Basin Inflow

Basin inflow (m^3/s) at start of simulation. Used only when assessing partially full basin.

Initial Water Level

Initial Basin Water Level (m) at beginning of the simulation.

Initial Basin Outflow

Initial Basin Outflow (m^3/s) at the beginning of the simulation to align with total level/discharge relationship and assumed initial water level in basin.

Storage Routing Interval

Volume routing increment (m3). The default value is 200 m3.

Consideration should be given to decreasing or increasing this volume to either maintain numerical stability in small basins or decrease computing time in bigger basins respectively.

A desirable volume routing increment should be less than 10% of expected Max. Basin Storage for numerical stability, and greater than 0.001% of the same to avoid time consuming basin routing simulations.

Non-Routed Baseflow

Non-routed baseflow under basin usually in underground conduit.

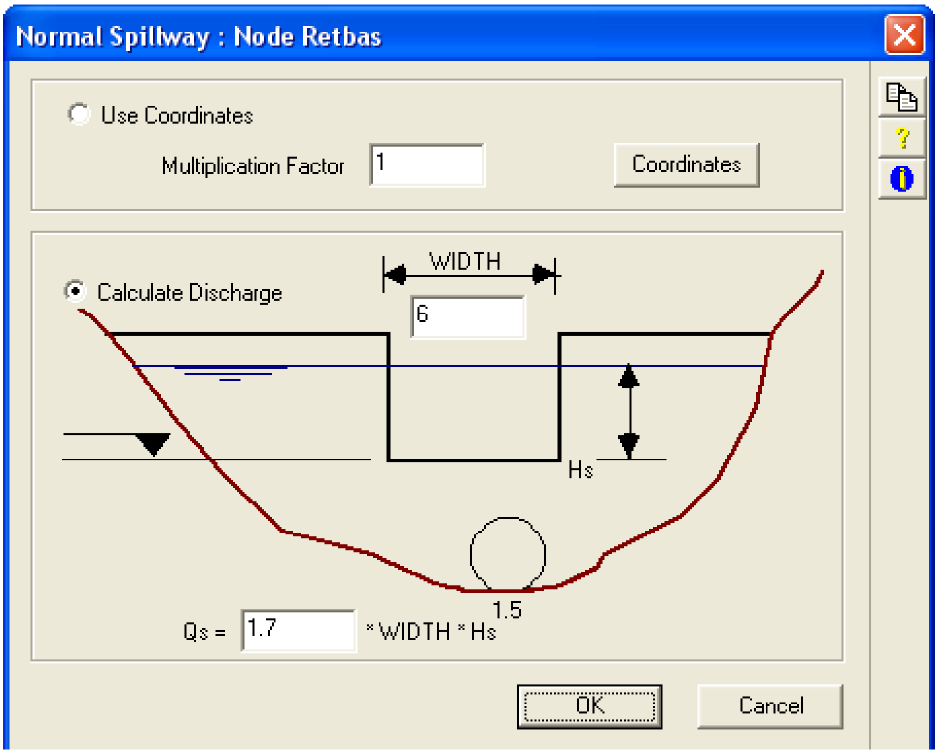
The non-routed discharge is optionally subtracted from the total inflow hydrograph to the basin so separate routing can occur. The basin outflow hydrograph is the combination of the routed surface flow plus the non-routed (but lagged) non-routed flow.

It is possible to examine the separate outflows under the full text outflow option.

Baseflow Lag Time

Lag time of non-routed baseflow through basin (minutes).

Normal Spillway



Normal Spillway

Contains all data for normal, non-erodible spillway.

Spillway Length

Effective spillway length (meters). Calculated spillway flows are then added to normal outlet level/discharge co-ordinate flows.

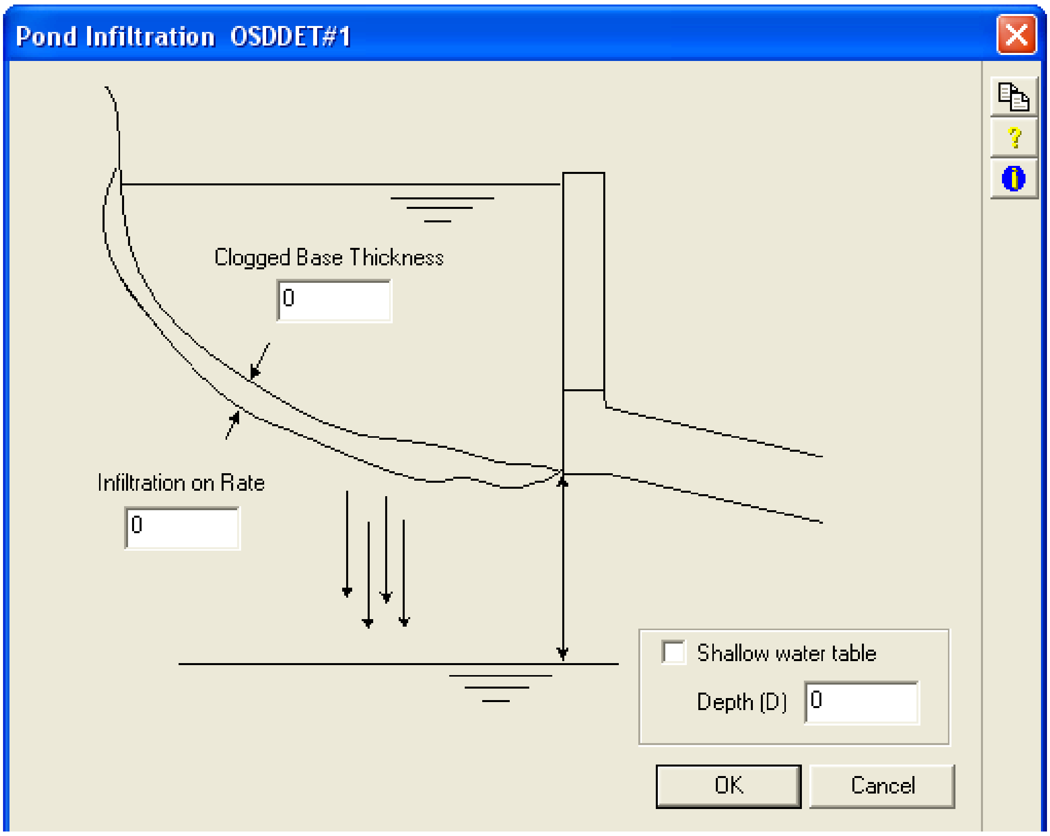
Multiplication Factor

Discharge values entered in the coordinates dialog will be multiplied by the value entered in this item.

Use Coordinates

If this option is selected Rafts expects the normal spillway to be described by way of level/discharge co-ordinates. Zero level in this case starts from the weir still level. Discharges are in m^3/s.

Infiltration



Pond Infiltration

RAFTS provides for leakage from basins and reservoirs in addition to evaporation losses and conventional outflow. Three strata situations are presently covered. These include a Shallow Water Table, Deep Water Table and Clogged Surface Layer. The equations utilize the work of Bouwer (1978), Bear et al (1968) and Todd (1980) to define shallow water table situations. The methods prescribed are similar to those utilized by Main Roads (Western Australia) PC SUMP(C) software.

Basin Infiltration Rate

Discharge through basin floor infiltration expressed in m/hr. This value represents the hydraulic conductivity of the basin floor.

Clogged layer

Thickness of clogged layer in meters. The Permeability value (or infiltration rate) in m/hr should now relate to this clogged layer.

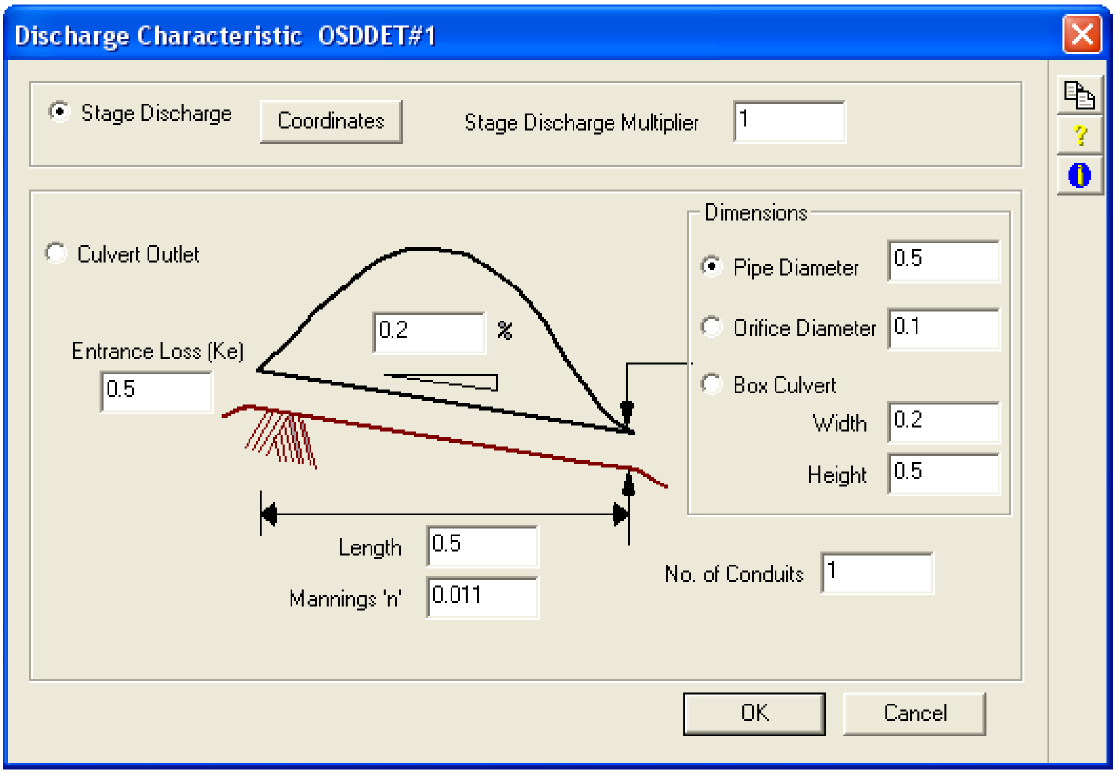
Water table

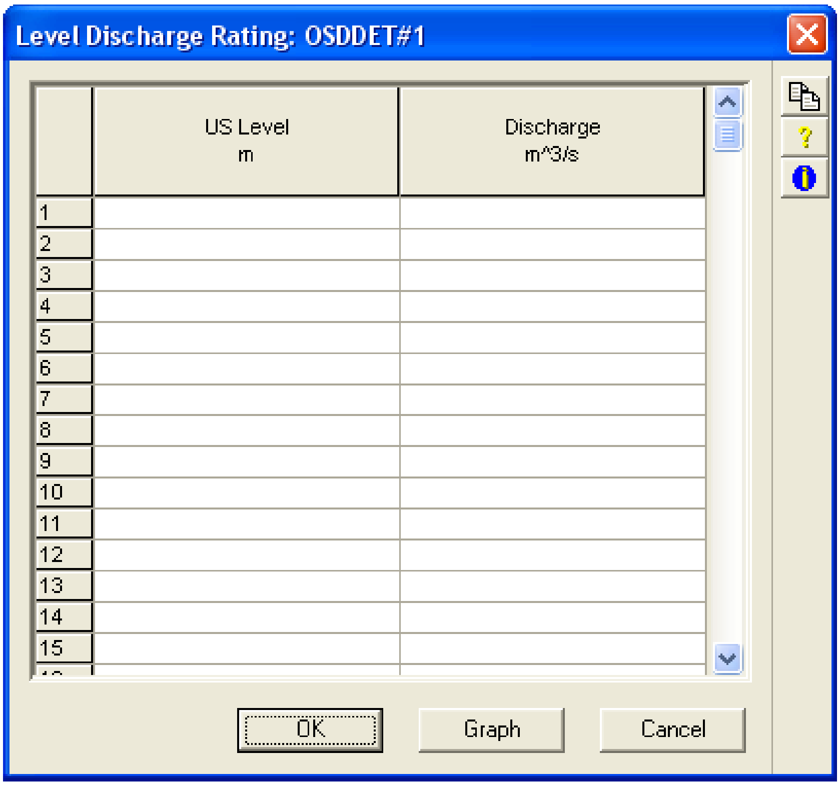
Depth of water table below the invert of the basin in meters. This option is only required if the 'Shallow water table' flag is turned ON.

Shallow Water table

Select this option to model a shallow water table at the given depth. If this flag is off then a deep water table is implied with no interaction with the infiltration flow.

Discharge





Stage Discharge: When this button is selected, xprafts expects level/discharge co-ordinates to define normal outflow discharge relationships. Level vs. Discharge data is only required if the 'Stage Discharge' option is selected. Click on the Coordinates button to open the data dialog.

Stage/Discharge Factor: Fractional multiplier of stage/discharge values

Conduit: When the culvert outlet radio button is selected, outflows calculated by appropriate equations.

Dimensions: Select the outlet geometry.

> **Pipe Diameter**: Pipe diameter (m).
>
> **Orifice Diameter:** Orifice diameter (m). Entrance loss, Slope, Length, Manning's 'n' and Culvert Method fields are ignored.
>
> **Box Culvert**: Data required for box culverts: height (m) and width (m).

Culvert Method (Std. Rafts): Culvert Stage/Discharge calculations carried out using traditional RAFTS equations described in manual.

Culvert Method (FHWA): Culvert Stage/Discharge calculations carried out using FHWA methods Not available at present

Entrance loss Coefficient: Culvert entrance loss coefficient default equal to 0.5

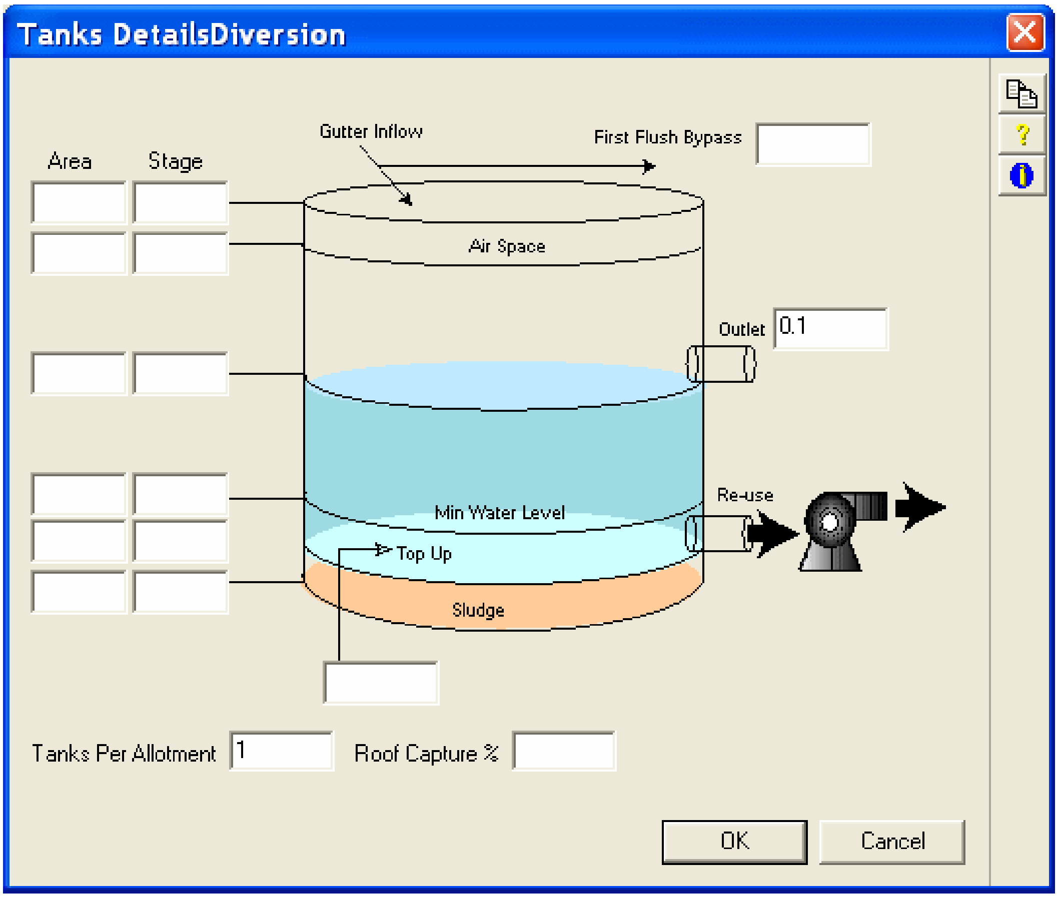
Culvert Slope: Slope of normal outlet conduit under embankment (%).

Pipe Length: Normal outlet pipe length under embankment (m).

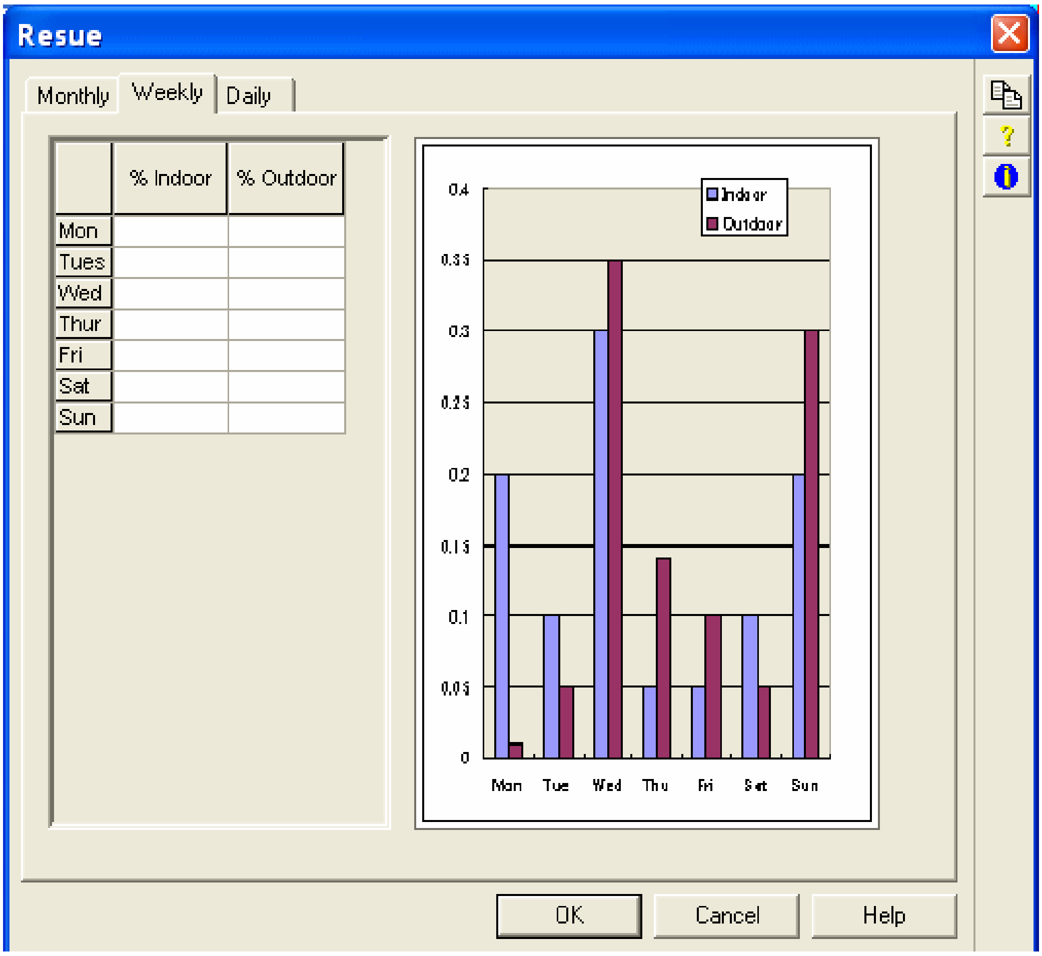
Manning's Roughness: Manning's roughness of culvert conduit.

No. of Conduits: Number of conduit barrels or orifices. All barrels are assumed equal.

Tank Detail



Reuse


Resue
Monthly
Weekly
Daily
% Indoor
% Outdoor
Mon
Tues
Wed
Thur
Fri
Sat
Sun
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Indoor
Outdoor
Mon
Tue
Wed
Thu
Fri
Sat
Sun
OK
Cancel
Help

9 - Link Data

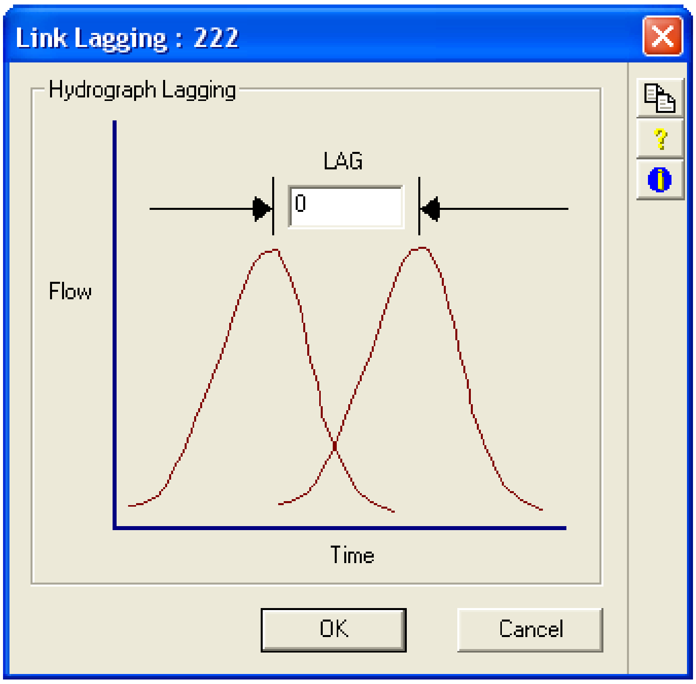
LINK DATA

To input or edit the attribute or model specific data associated with a link either "double-click" on the link or select the link and choose the "DATA" command from the Edit Menu.

Three types of links are presently supported in xprafts: a simple Lagging Link, a Routing Link and a Diversion Link. Diversion links are created with the Diversion Link

LAGGING LINK DATA

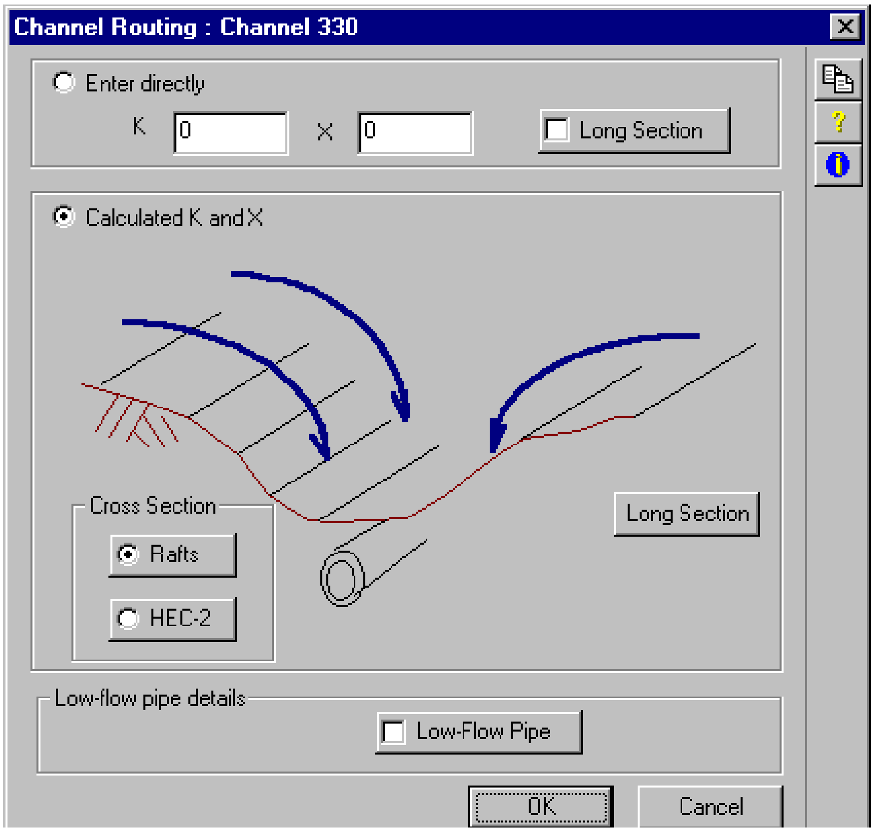
A solid link represents a simple lagging link.



The only data required for this element type is the travel time (in minutes) for the peak flow to travel the length of this reach.

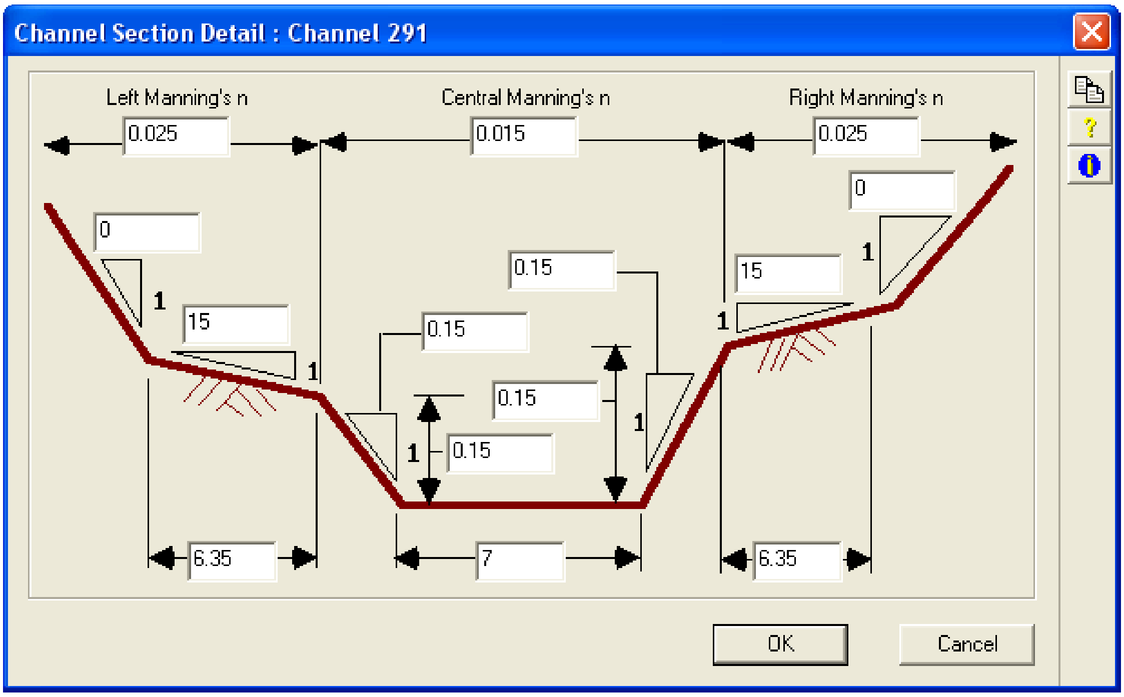
ROUTING LINK DATA

A dashed link representing a link with explicit flow routing applied.



The channel cross section can be described in Rafts format or in Hec-2 format. If Hec-2 format is selected it is possible to read data from existing Hec-2 data files.

Rafts Cross Section

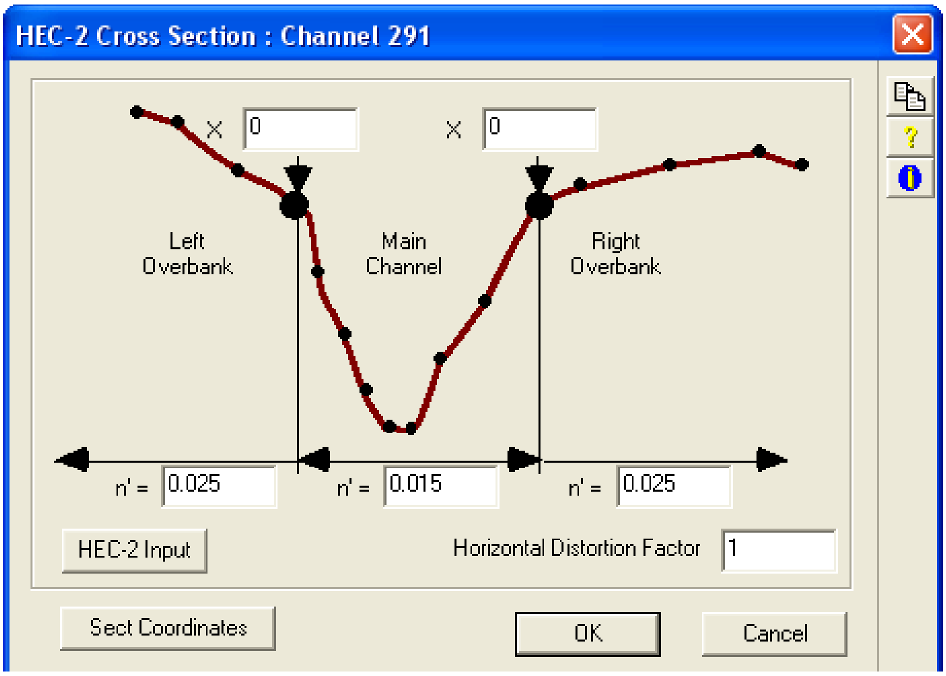


Rafts Cross Section

If the Rafts Cross Section option is selected you will be required to enter the channel shape as a list of channel slopes and widths, as an extended trapezoidal cross-section.

Hec2 Cross Section

The conduit may be defined as a Circular conduit, non-circular conduit or a Box culvert.



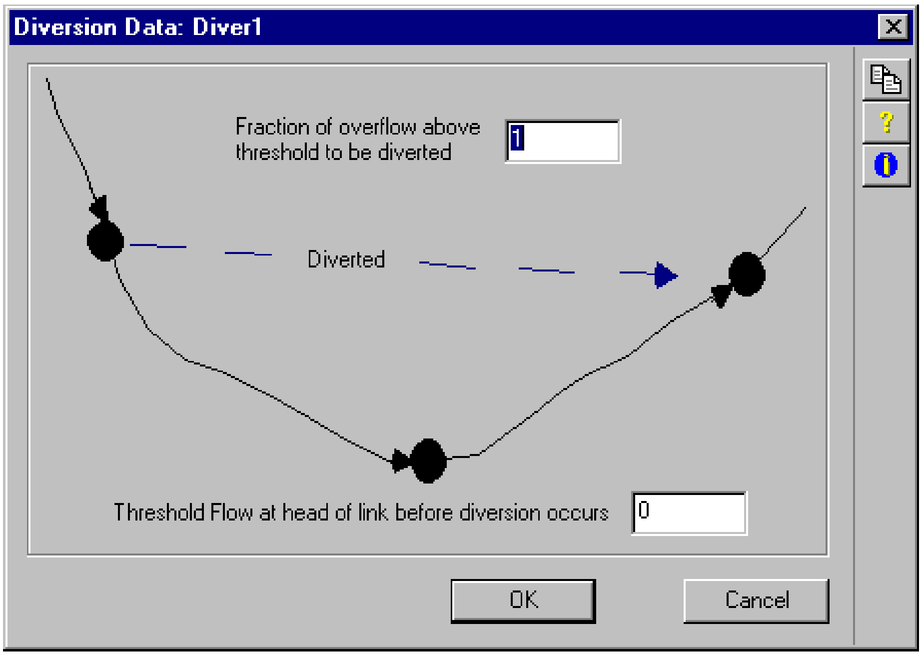
Hec-2 Cross Section

If the Hec-2 cross section option is selected you will be required to enter the channel shape as a table of horizontal station positions and vertical elevations. The station positions of the left and right overbanks must also be entered.

The model computes channel hydraulic properties in a manner compatible with the default behaviour of Hec-2. All parts of the cross-section below the water level are assumed to be conveying flow. The ends of the cross-section are assumed to be extended vertically with frictionless walls.

If data for the channel already exists in Hec-2 format this data can simply be read in from the Hec-2 file.

DIVERSION LINK DATA



An overland diversion is a special type of link object shown in a network as a dashed line.

Primary Overflow Path

The primary overflow path may be the next downstream pit in the network or it may be any other pit in the network. This path represents the preferred or priority direction of flooded node flows.

Primary Overflow Characteristics

These are the characteristics applying to the designated primary overflow path.

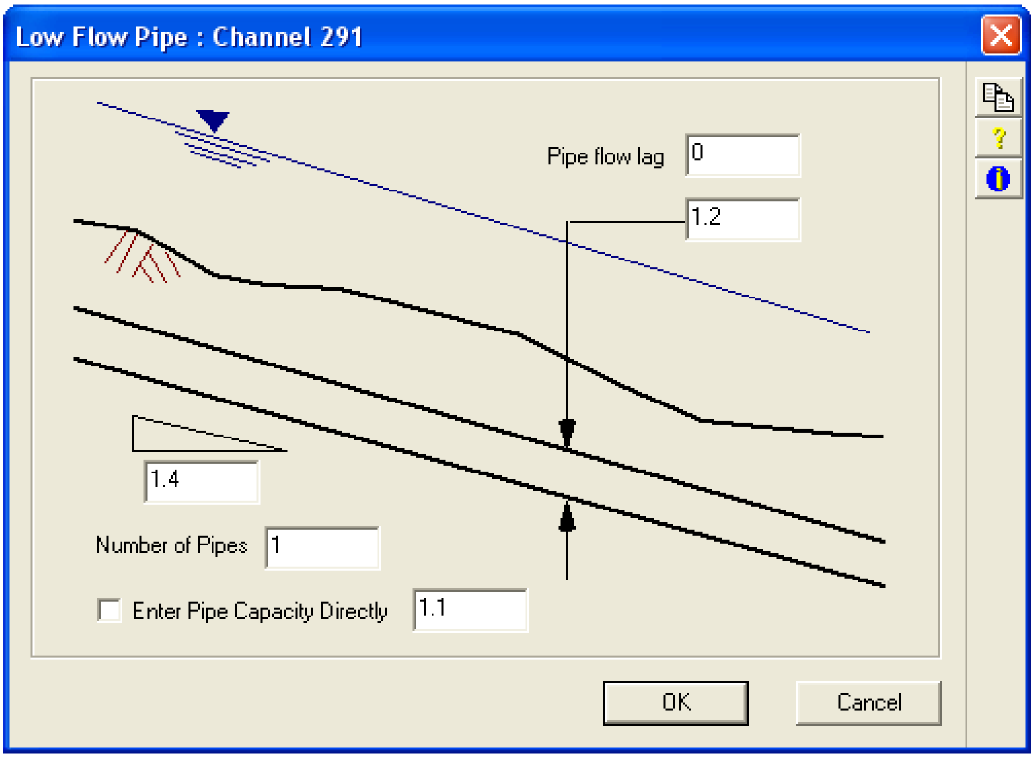
Flow Threshold)

Flow (m^3/s, ft^3/s reached in primary path before any diversion occurs.

% of Surcharge above Threshold

Fraction of flow above threshold that continues to flow down the primary flow path.

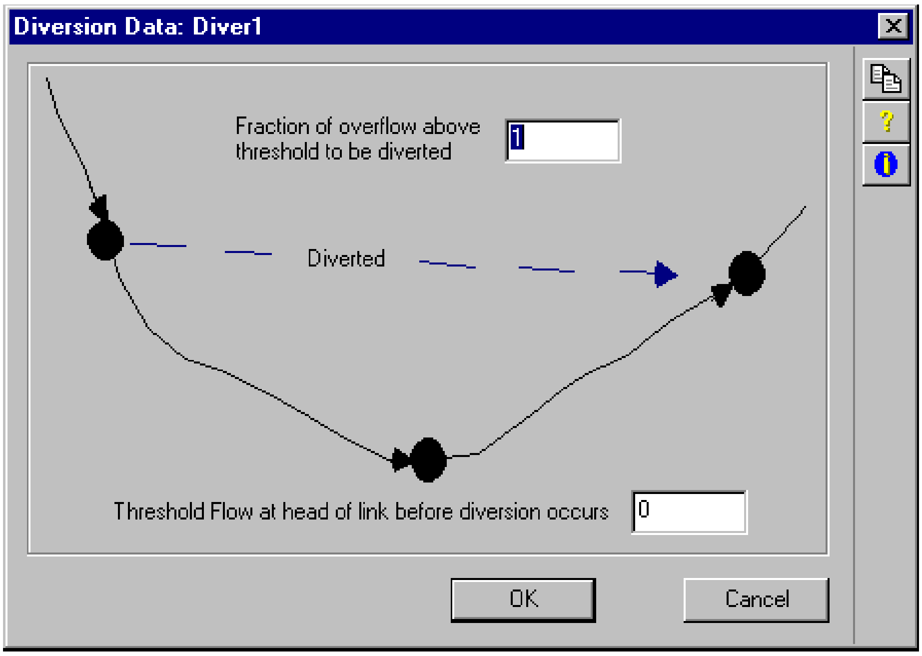
Low Flow Pipe



This group of data describes any pipe under the channel section. If a pipe slope is provided greater than 0.0% with no diameter RAFTS will estimate using Manning's Equation a pipe diameter to just contain the total inflow hydrograph at the top of the link after basin routing if present.

Natural surface information may be entered for any reach in the system. The offset "x" (m, ft) and the elevation (m, ft) is entered into the table shown. These values are additional to the cover level entered for each pit, which is assumed to be a design level. Any number of values may be entered between each pit. The Natural Surface profile is used when checking cover requirements following a Design run or prior to an Analysis run. Any conflicts are reported to the error log and may be viewed as usual. Note that if both a Design Surface and Natural Surface are defined, then the Design Surface takes precedence in the checking that is performed.

DIVERSION LINK DATA



An overland diversion is a special type of link object shown in a network as a dashed line.

Primary Overflow Path

The primary overflow path may be the next downstream pit in the network or it may be any other pit in the network. This path represents the preferred or priority direction of flooded node flows.

Primary Overflow Characteristics

These are the characteristics applying to the designated primary overflow path.

Flow Threshold)

Flow (m^3/s, ft^3/s reached in primary path before any diversion occurs.

% of Surcharge above Threshold

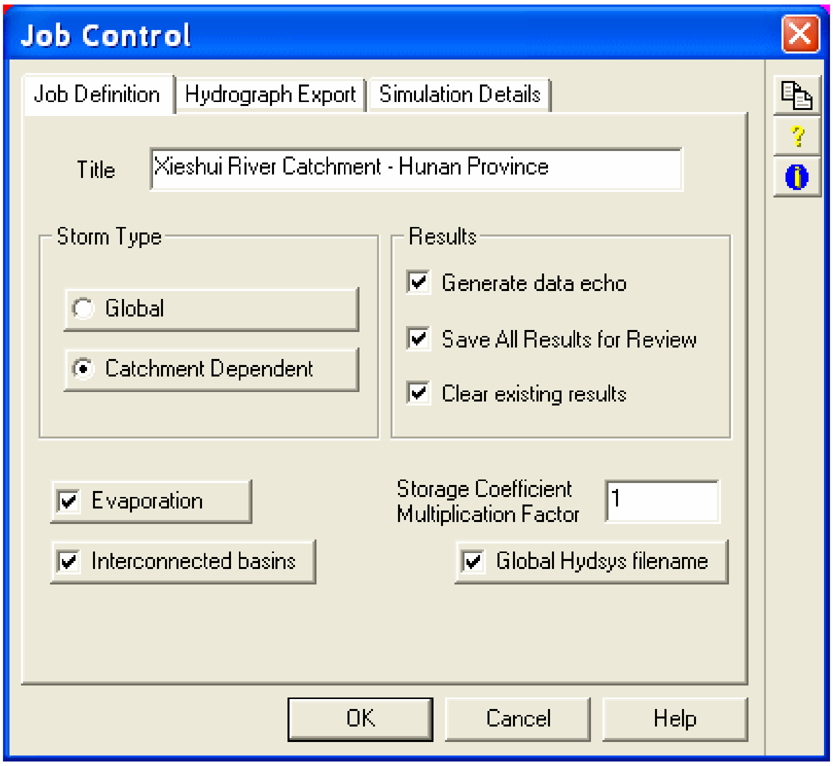
Fraction of flow above threshold that continues to flow down the primary flow path.

10 - Job Control

JOB CONTROL INSTRUCTIONS

The job control instructions are managed with three dialogs. Use the tabs to navigate.

Job Definition



Title

The title of the simulation or run should be entered. This title should be descriptive and distinguish this run for other similar runs.

The Storm Type is either:

Global

Catchment Dependent

Automatic Storm Generator

Evaporation

Generate Data Echo

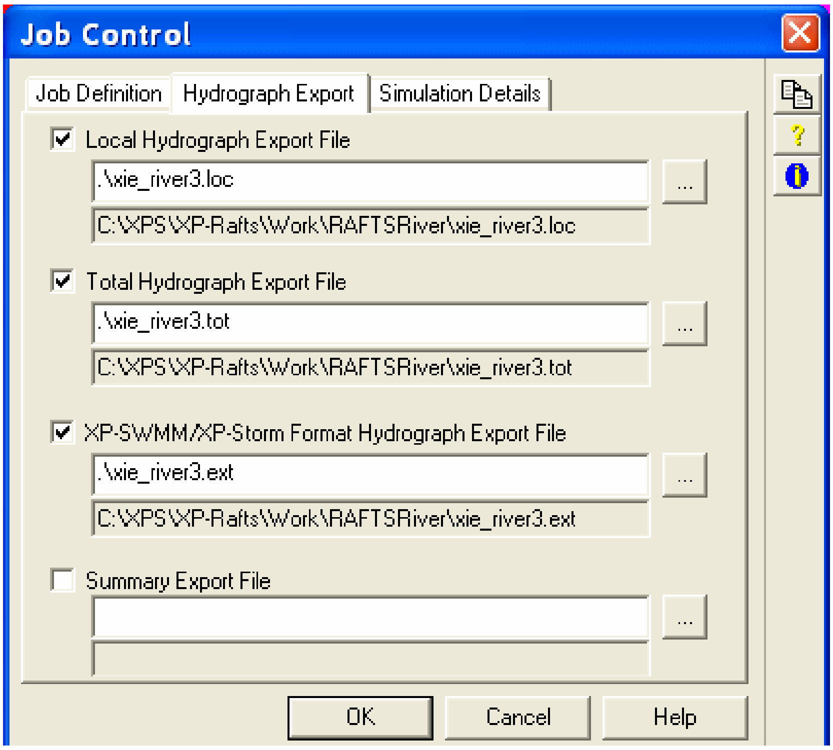
Save All Results for Review

Storage Coefficient Multiplication Factor

Interconnected Basins

Global Hydsys Filename

Hydrograph Export



Use this dialog to manage the node Hydrograph Export during a model solve.

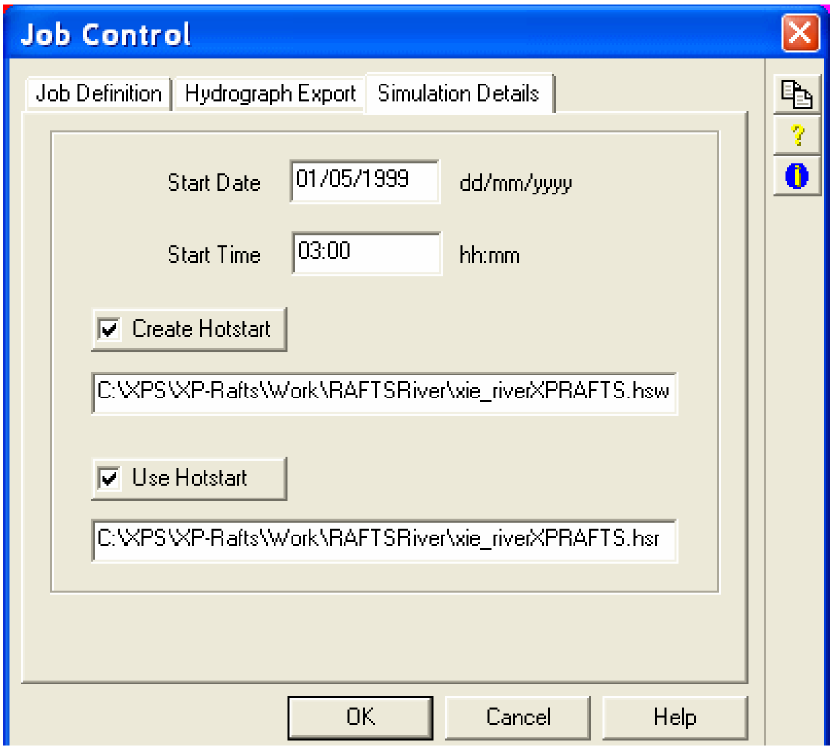
Local Hydrograph Export File

Total Hydrograph Export File

xpswmm/xpstorm Format Hydrograph Export File

Summary Export File

Simulation Details



Start Date

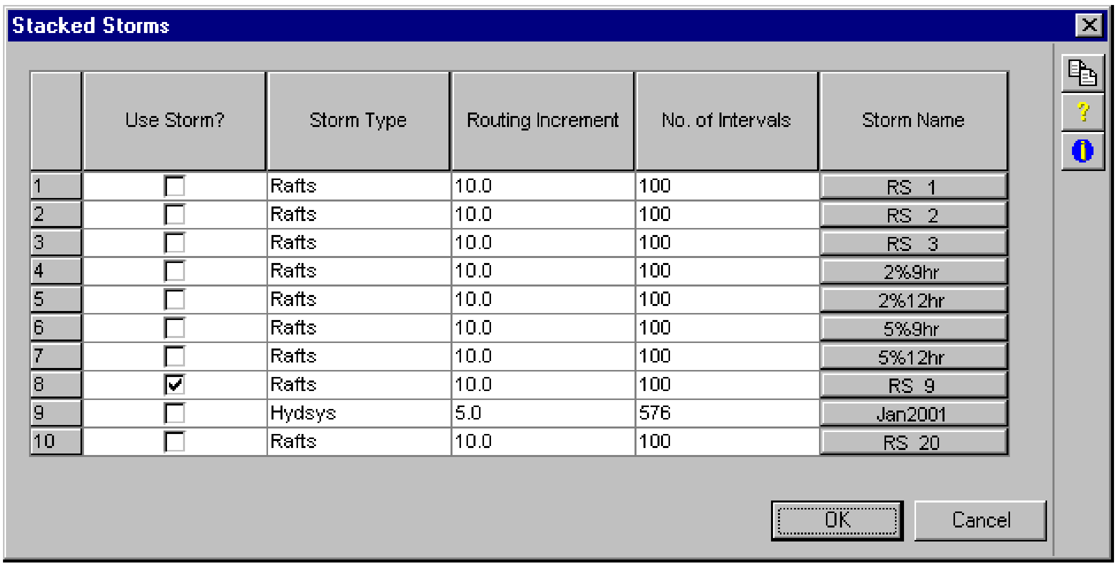
Start Time

Create Hotstart File

Use Hotstart File

Job Definition

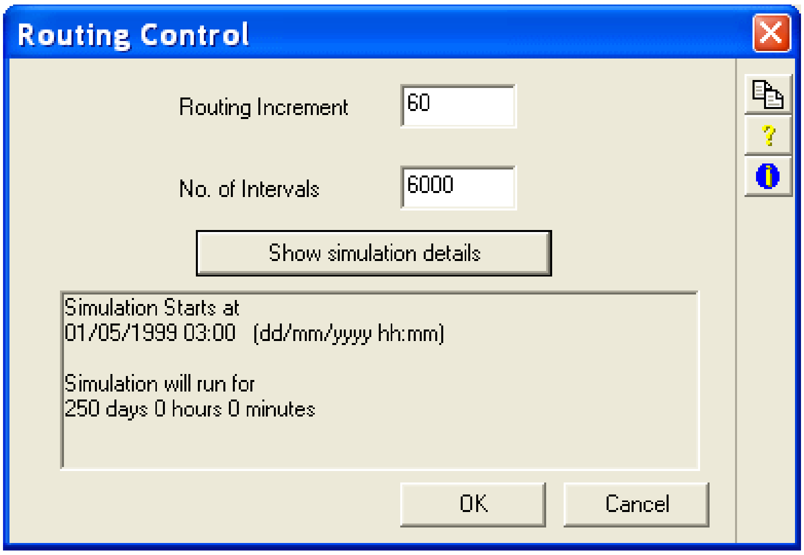
Global Storm



Stormwater Modeling: A global storm is a representative storm which is applied uniformly over the complete catchment. Typically a global storm is a design storm which is input as a dimensionless temporal pattern combined with an average rainfall intensity.

Sewer Modeling: To estimate dry weather sewage flows average intensity is input as 1/d/24 per EP. This value is scaled into a dimensionless temporal pattern (entered under temporal pattern menu) to represent the local instantaneous diurnal flow hydrograph to a node. To conserve this input flow pattern without any further routing to the node, it is necessary to input a 100% impervious percentage within the sub catchment data. Wet weather sewage infiltration flows utilize normal storm intensity and temporal pattern data.

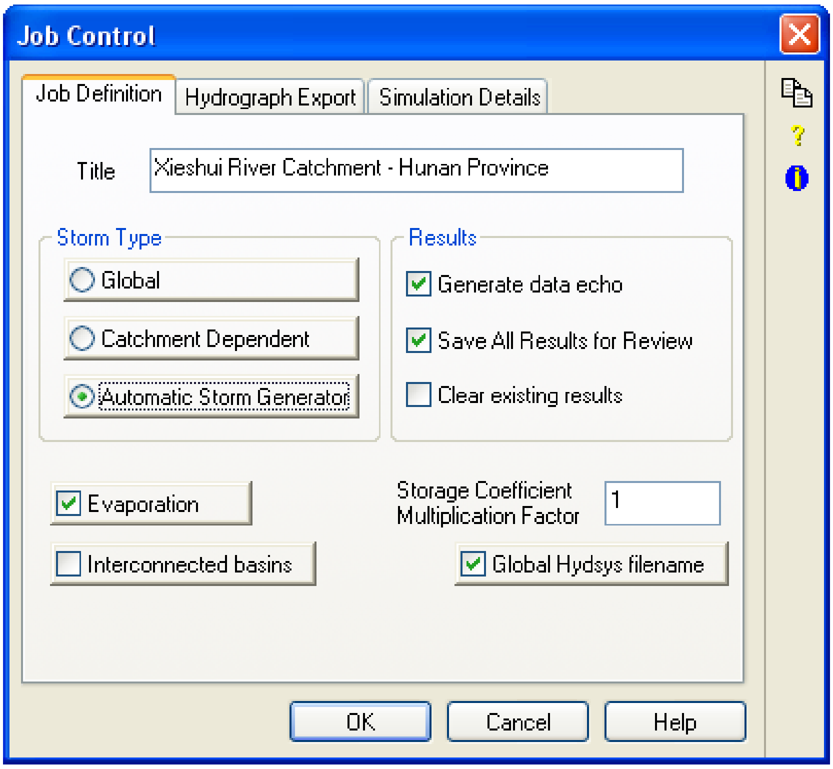
Catchment Dependent Storm



Stormwater Modeling: Observed spatial and temporal variations in historical rainfall events may be simulated by applying different rainfall data for each subcatchment according to rainfall and pluviograph records.

Sewer Modeling: To estimate dry weather sewage flows average intensity is input as 1/d/24 per EP. This value is scaled into a dimensionless temporal pattern (entered under temporal pattern menu) to represent the local instantaneous diurnal flow hydrograph to a node. To conserve this input flow pattern without any further routing to the node it is necessary to input a 100% impervious percentage within the sub-catchment data. Wet weather sewage infiltration flows utilize normal storm intensity and temporal pattern data.

Automatic Storm Generator

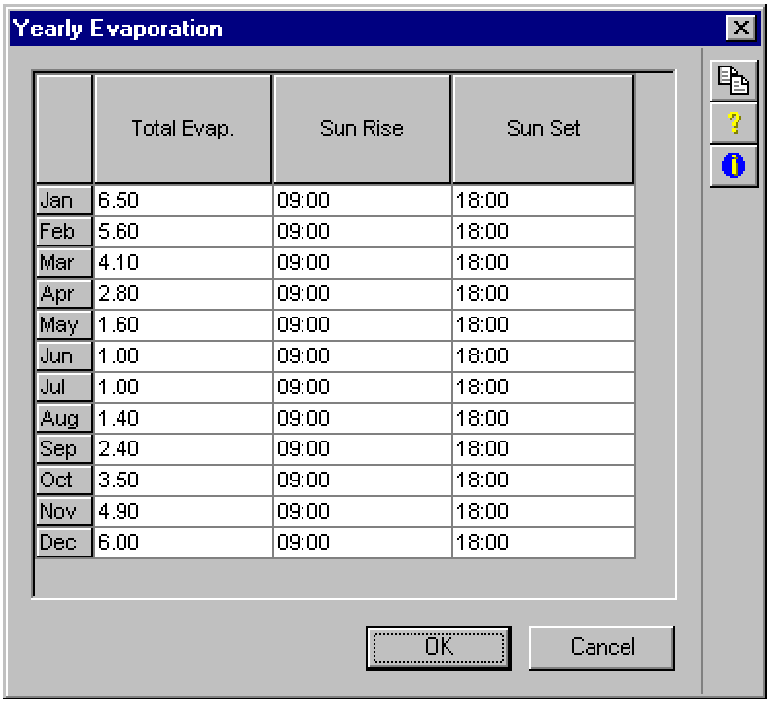


RAFTS will automatically generate design storms from the IFD curves and temporal patterns. It will calculate the probable maximum precipitation (PMP) for the short or long durations.

Global Storm Generator

PMP

Evaporation



	Total Evap.	Sun Rise	Sun Set
Jan	6.50	09:00	18:00
Feb	5.60	09:00	18:00
Mar	4.10	09:00	18:00
Apr	2.80	09:00	18:00
May	1.60	09:00	18:00
Jun	1.00	09:00	18:00
Jul	1.00	09:00	18:00
Aug	1.40	09:00	18:00
Sep	2.40	09:00	18:00
Oct	3.50	09:00	18:00
Nov	4.90	09:00	18:00
Dec	6.00	09:00	18:00

Evaporation data is optional and is usually used when applying the soil infiltration module (ARBM). Pan Evaporation Data is input as average mm/day values for each month with appropriate mean monthly sunrise and sunset values in decimal hours.

Yearly Evaporation - Evaporation data is only required when using the infiltration option for estimating excess rainfall and/ or including evaporation from reservoirs. Data is entered in mm/day averaged over a month.

Time of Sunrise and Sunset is also entered in hours and minutes in 24 hour format to limit evaporation to daylight hours.

Evaporation from Basins – Whenever evaporation data is entered within the job control dialog evaporation loss from basins/reservoirs is included. The amount is aligned to the simulation date and time.

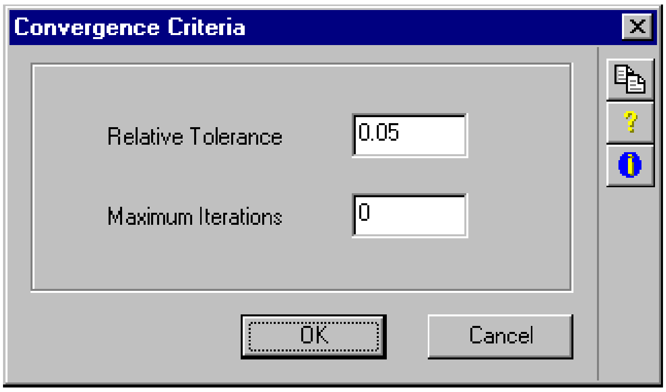
Evaporation overflows are lost from the system and directly affect the draw down in the basin in conjunction with the normal outlet works.

Surface areas are back computed from the level/storage rating curve and actual evaporation is estimated as the potential evaporation defined in Jobs Control data over the time step multiplied by an actual/potential adjustment factor. The hardcoded default adjustment factor is 0.9. This factor can be adjusted by employing the ARBM infiltration module on the subcatchment outletting to the basin. In this manner the input actual/potential evaporation ratio will be used.

If split sub-catchments are utilized the second subcatchment actual/potential factor will be used. Evaporation and surface areas are output in basin output table under full output option.

When large reservoirs are being considered use of split sub-catchments may be necessary to maintain the catchment/reservoir surfacewater balance.

Interconnected Basins



This option should be flagged in the check box when it is expected that a downstream basin may affect the outlet hydraulics of upstream basins.

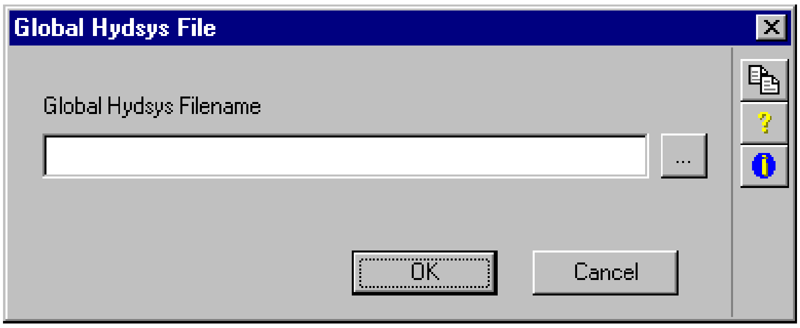
Tolerance – tolerance of convergence criteria when comparing successive interconnected basin runs. The default difference between any flow peaks is 0.05 cumecs.

Iterations – Maximum number of iterations to compare successive interconnected basin runs. If the tolerance criteria is met before the maximum the n RAFTS jumps out of the iterative loop. If the tolerance criteria is not met within the maximum set, the last values are adopted. Normally it takes 2 to 4 iterations to solve.

Storm Type

Whether RAFTS storm or Hydsys storm.

Global Hydsys Filename



This is used to indicate single hydsys files containing all storm and hydrograph data. The file name must have the correct and full path names. This name will then be used by all Hydsys storms and hydrographs, overriding any existing selections.

Results

Check the boxes next to the desired results options:

Generate data echo

Save All Results for Review

Clear Existing Results

Generate Data Echo

When this option is selected, an echo of input data is produced at the beginning of the output file.

Storage Coefficient Multiplication Factor

During calibration of a gauged catchment the Storage Coefficient Multiplication Factor (BX) may be used to modify the calculated storage time delay coefficient (B). The Storage Coefficient Multiplication Factor uniformly modifies all subcatchment Storage Time Delay Coefficient values previously computed or determined from the default equation. The default value for the Storage Coefficient Multiplication Factor is 1.0. Refer to Section 14 for more details.

Hydrograph Export

Local Hydrograph Export File

Click on the ellipses (…) to navigate to the location of the file. Check the box to enable export.

File definition for local hydrograph file. Define full paths names. Hydrographs are individually tagged within node dialogs. The following indicates the format specifications of the ASCII text file for both and total hydrographs.

Start file

JOB, NLKS, NVAL, DT	(3i5, g12.5)		
Repeat next two lines for NLKS links			Repeat
linkno.	linklab	(g10.2. a10)	for each
q (k),	I=1, nval (5g 12.5)		stacked
			storm

End of file

JOB	Strom event number
NLKS	No of tagged links in file
NVAL	No of routing increments in hydrograph
DT	Length of routing increment in minutes
linkno	Link number of tagged hydrographs
linklab	Link label of tagged hydrograph
q (i)	Hydrograph ordinates in m3/s

Note: All hydrographs refer to input to the top of the link before basin routing.

Total Hydrograph Export File

Click on the ellipses (…) to navigate to the location of the file. Check the box to enable export.

File definition for total hydrograph file. Define full path names. The format specifications of the ASCII text file for both local and total hydrographs are the same.

xpswmm/xpstorm Format Hydrograph Export File

Click on the ellipses (…) to navigate to the location of the file. Check the box to enable export.

File definition for SWMM interface file.

FILE	WRITE (NOUT)	TITLE (1), TITLE (2)
HEADER	WRITE (NOUT)	IDATEZ, TZERO
	WRITE (NOUT)	TITLE (3), TITLE (4)
	WRITE (NOUT)	SOURCE, LOCATS, NPOLL, TRIBA
	IF (JCE.EQ.0) WRITE (NOUT)	(NLOC (K), K=1, LOCATS)
	IF (JCE.EQ.1) WRITE (NOUT)	(KLOC (K), K=1, LOCATS)
	IF (NPOLL, GT.0) WRITE (NOUT)	
		((PNAMEL (L,J), L=1,2), J=1, NPOLL)
	IF (NPOLL.GT.0) WRITE (NOUT)	
		((PUNIT (L,J), L=1,2), J=1, NPOLL)
	IF (NPOLL.GT.0) WRITE (NOUT)	(NDIM (J),J=1, NPOLL)

WRITE (NOUT) QCONV

NOUT is the interface file or logical unit
Number for output, e.g., NOUT = JOUT (1) for
first computational block.

REPEAT FOR EACH TIME STEP WRITE (NOUT) JULDAY, TIMDAY, DELTA, (Q(K), K=1, LOCATS)

NOTE: The interface file in binary format is complier dependant. XP files utilise the Microsoft complier.

Summary Export File

Click on the ellipses (…) to navigate to the location of the file. Check the box to enable export.

Simulation Details

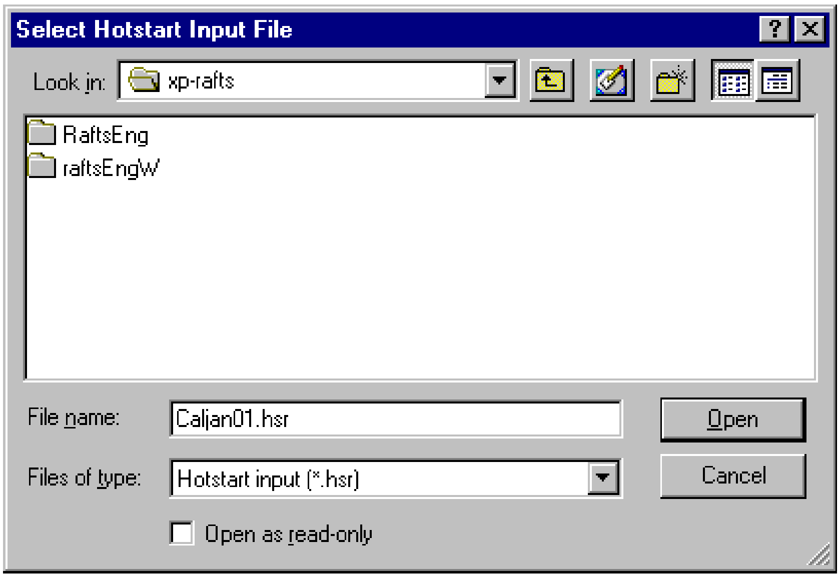
Start Date

Simulation start date.

Start Time

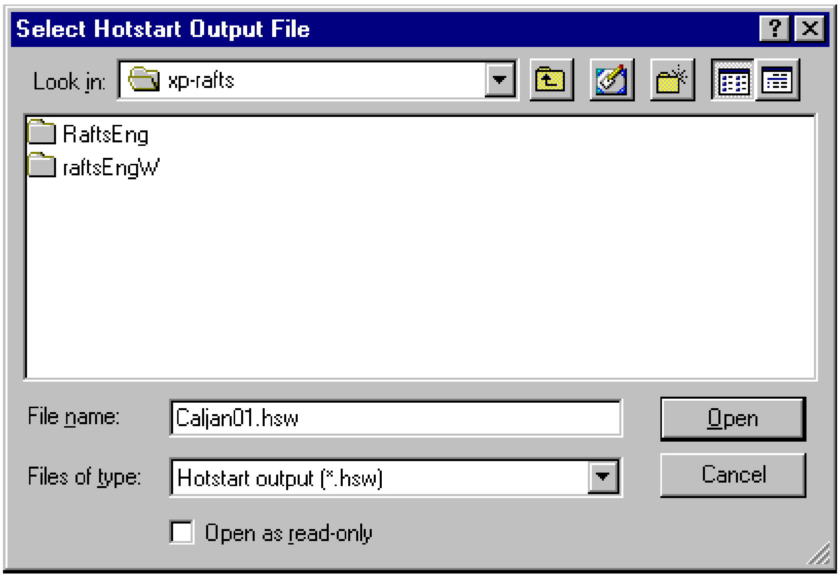
Simulation start time.

Use Hotstart File



Check box to use a hotstart file containing initial conditions. In Windows Explorer, navigate to file location.

Create Hotstart File



Flag to create a new hotstart file. Hotstart files allow you to run a length of data say for a month before an event and save the end conditions for use as starting conditions for other events. All conditions including basin levels, soil stores, etc. are stored in the file.

11 - Global Data

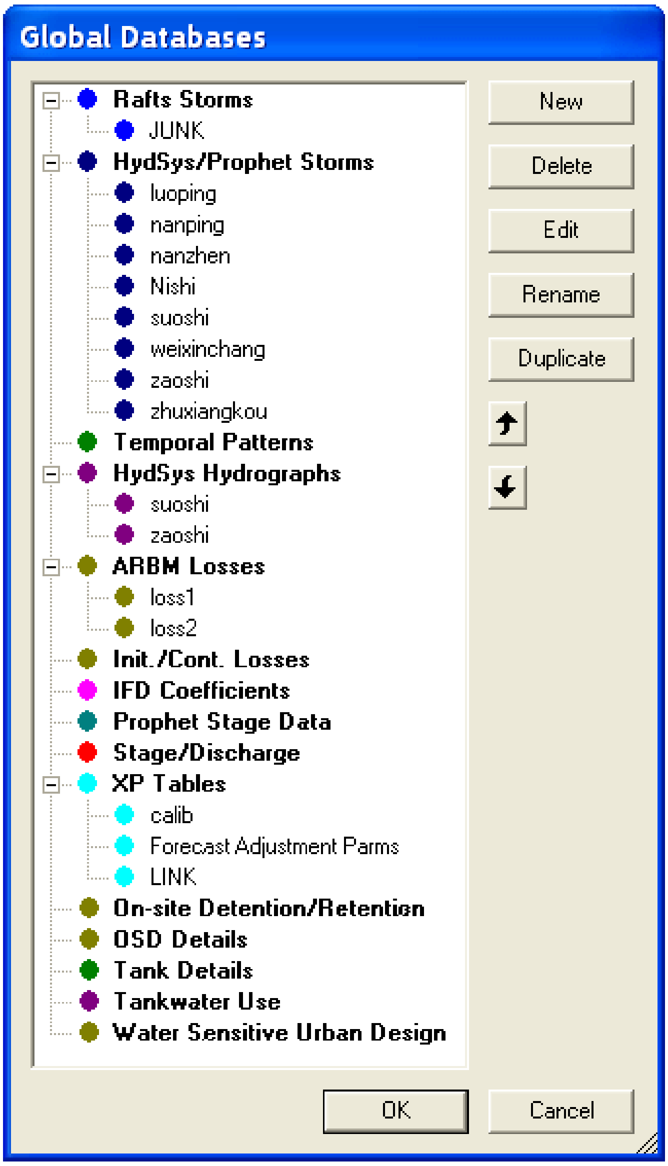
GLOBAL DATA

This command allows the management of databases of information that may be referenced from individual nodes or links. This reduces data redundancy dramatically and associated problems of updating at many places when changes are made. A full description of the parameters used by RAFTS follows.

Each global database type relates to a grouping of related data items. There can be any number of database records for each database type.

Each database record has a name, which will be referenced from a node or link dialog (or Job Control), and a description. Hitting the Edit button causes the dialog containing the data for the highlighted Database Type and database Record Name to be displayed.

Ten types of database records are available. The database type is displayed in the left-hand side scrollable list below this heading. As each database type is selected, the list of available records in that database is displayed in the list to the right. This list is created and maintained by the user. The list to which keystrokes, such as arrow keys, <page-up>, <page-down>, <home>, <end>, <insert>, <delete>, etc. will be directed is highlighted with a bounding rectangle. Either list can be made the active list by clicking in it.



The ten available database types are:

RAFTS Storms

Hydsys/Prophet Storms

Temporal Patterns

Hydsys Hydrographs

ARBM Losses

Initial/Continuing Losses

IFD Coefficients

Prophet Stage Data

Stage/Discharge Data

XP Tables , which may be used to examine or edit data in a spreadsheet-type, format.

On-Site Detention/Retention

OSD Details

Tank Details

Tankwater Use

Water Sensitive Urban Design

Global Data Items

This scrollable list displays the available records from the current Database Type. The buttons on the right-hand side of the list manipulates this list. You can duplicate, add, rename, edit, delete and copy records to this list using the appropriate buttons. This list can be navigated in the same way as the database type list, ie. arrow keys, <page-up>, <page-down>, etc.

The edit item immediately below the Record Name List contains the name of the currently highlighted database record. Edit this item before adding or renaming a database record. This name will be used when the database record is referenced from a node.

New

Hit this button to add a database record, of the currently highlighted type, with the name and description entered below. Note that this action is not committed until OK is hit or another database type is selected.

Delete

Hit this button to delete the currently highlighted database record. The action is performed when OK is hit or another database type is selected.

Edit

Hit this button to edit the data required for the currently highlighted database record.

Rename

Hit this button to rename the currently highlighted database record. To change the name of a database record that is displayed in the list box shown above you must:

The data for the original name will now be attached to the new name and the old name will no longer appear in the list box. The command is executed when OK is hit or another database type is selected.

Duplicate

Hit this button to duplicate the highlighted database record. The new Record Name will have a .1, .2 etc. extension appended to the original name.

Copy

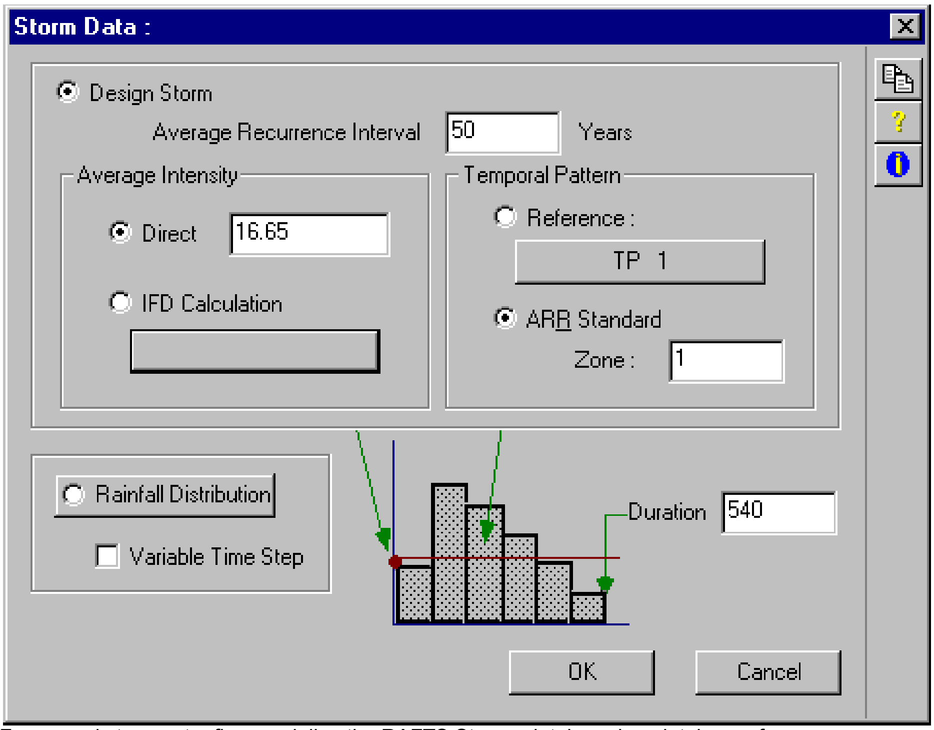
Hit this button to copy the currently highlighted database record to the copy buffer for pasting into another project data file. To paste these records go to the network and select Paste (or Alt V). Every time you select paste a new database record will be created with its contents those of the copy buffer created above. If the paste operation should result in conflicting record names, new names, based on the original name with a numerical extension, will be created for those records. See Section 4 for a complete description on Copy & Paste.

Description

Description of the database record. This item may be any meaningful description of the current database record of the current database type. This field is for annotation; the model does not use it.

Global Database Records

RAFTS Storms



For normal stormwater flow modeling the RAFTS Storms database is a database of average recurrence interval, storm duration and rainfall data.

Design Storm: This option accepts an average intensity in conjunction with a dimensionless temporal pattern usually in the form provided in ARR 1987 for design storm events.

Average Recurrence Interval: The Average Recurrence Interval (ARI) is the interval in years at which, on average, the storm will re-occur.

Average Intensity: The average Intensity is the average rainfall intensity which is obtained by dividing the total rainfall depth by the total storm duration. The units of rainfall intensity are mm/h (SI Units).

Temporal Pattern Reference: The Temporal Pattern Reference is the name of the associated storm temporal pattern from the Temporal Pattern database.

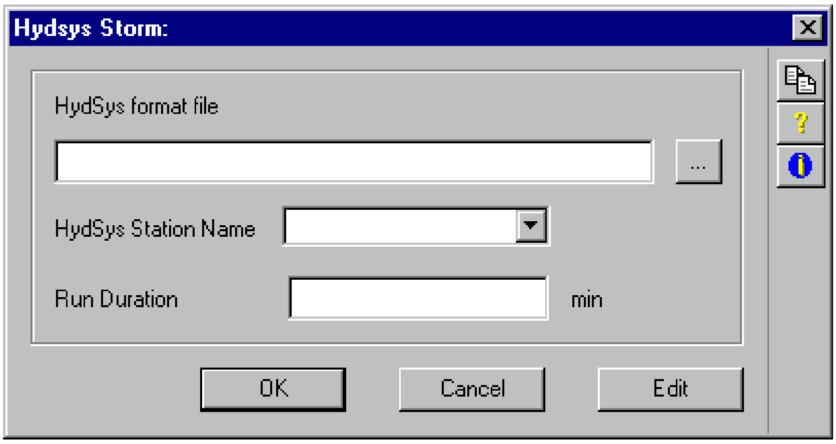
AR & R Standard Zone: This option allows for the eight standard temporal pattern zones defined in Volume 2 of Australian Rainfall & Runoff (1987)

Rainfall Distribution: This option is used as an alternative to the Design Storm option when entering real (historical) storm data. The unit of rainfall is millimeters.

Variable Time Step: This option allows rainfall data to be entered in uneven time steps. It is used when longer events of days, weeks or months are being simulated and it is used in conjunction with the “Rainfall Distribution” option. The time interval is in minutes and the rainfall amount is in millimeters.

Duration: The duration is the total storm duration in minutes. The duration is used to calculate the interval used in the temporal pattern of the design and also the interval for the Rainfall Distribution option if a variable time step is not selected.

Hydsys/Prophet Storms



Definition of hydsys gauged rainfall data.

HydSys Format File: The name of the file which contains the rainfall intensity or stream flow information. If the “Select” button is activated then a get file dialog presented, allowing the user to choose the appropriate file. You may create your own file by entering the name of a non-existing file in this field.

HySys Station Name: A number identifying the station for which data is held in the file defined above. Typically the name of the field station of interest. You may create a new station name by entering a non-existing name in this field.

Run Duration: The HydSys data must at least span this period with the first date and time being the same as or prior to the input start time and date in the Job Control dialog.

When the number of routing intervals multiplied by the routing increment is shorter than this Run Duration continuous modeling will be automatically instigated with the partition length equal to the number of routing intervals multiplied by the routing increment.

A typical partition can be set at one day when routing at 5 minutes by setting the number of increments to 288.

Sort Button: Use the sort button to sort the list chronologically.

HydSys Date: This item specifies the end date for the value on the current row (except for the first row) and the start date for the value on the following row (except for the last row).

HydSys Time: This item specifies the end time for the value on the current row (except for the first row) and the start time for the value on the following row (except the last row).

HydSys Rainfall: This item specifies the rainfall for the period starting at the date and time of the previous row and ending at the date and time of the current row. The rainfall value for the first row is ignored.

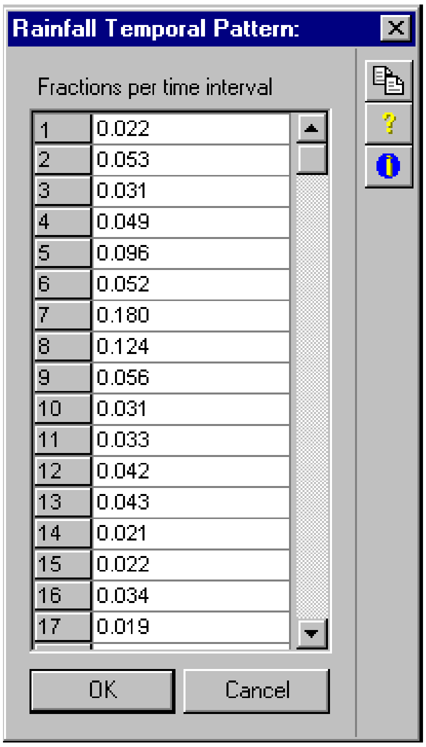
HydSys Discharge: This item specifies the discharge for the period starting at the date and time of the previous row and ending at the date and time of the current row. The discharge value for the first row is ignored.

Rainfall/Streamflow File Format

Station	Variable	Year	Month	Day	Hr	Min	Value
A8	f7.0	I4	I2	I2	I2	I2	f12.0

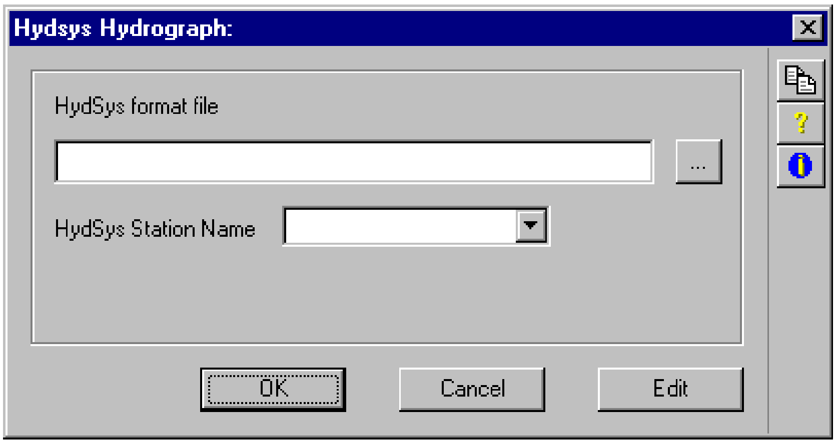
The variable defines whether the value is rainfall (mm) or runoff (m3/s). Variable=10=Rainfall, Variable=140=Runoff.

Temporal Patterns



Definition of temporal pattern either dimensionless or in mm to be used in conjunction with “Rafts Storm” data.

Hydsys Hydrographs



Definition of hydsys gauged hydrograph data.

HYDSYS type Rainfall and Streamflow Data Importation: Version 2.70 and later read HYDSYS rainfall and streamflow data from disk.

The file format is explained below. It is a simple ASCII file which has been generated by the HYDSYS data archiving system as a report file.

In this manner any time series data storage and retrieval system that can output formatted ASCII files can be used to export rainfall or streamflow data to XP-RAFTS.

Rainfall/Streamflow File

Station	Variable	Year	Month	Day	Hr	Min	Value
A8	f7.0	I4	I2	I2	I2	I2	f12.0

The variable defines whether the value is rainfall (mm) or runoff (m3/s). Variable=10=Rainfall, Variable=140=Runoff.

The XP-RAFTS simulation period must occur after the start of the first file date/time record. If the simulation period extends past the date in the record zero values are assumed for the remainder of the simulation.

One file can contain all of the rainfall and streamflow stations likely to be utilized in the simulation or separate files for each station and variable type can be utilized if preferred.

Current HydSys File Size Restrictions: XP-RAFTS currently allows editing of up to 10,000 data points. Using the Protected Mode version of XP-RAFTS run durations that use up to 5,000 variable time-step values may be solved. Limits for the Real Mode version are memory dependent but will be considerably less than these values.

ARBM Losses

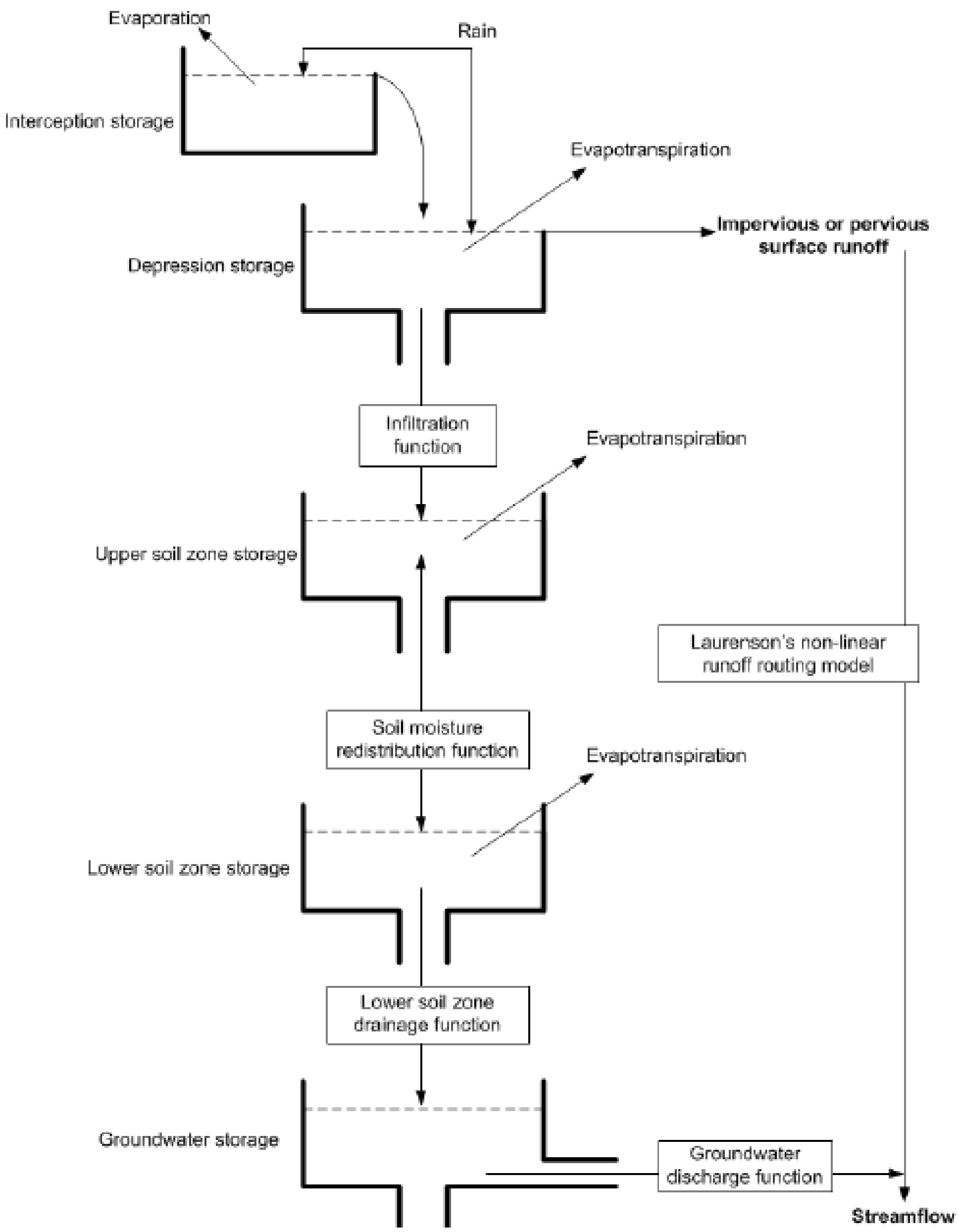
The Australian Representative Basins Model (ARBM) originally developed by Chapman (1968) to describe catchment infiltration and subsequent rainfall excess for a particular rainfall sequence plus catchment antecedent condition.

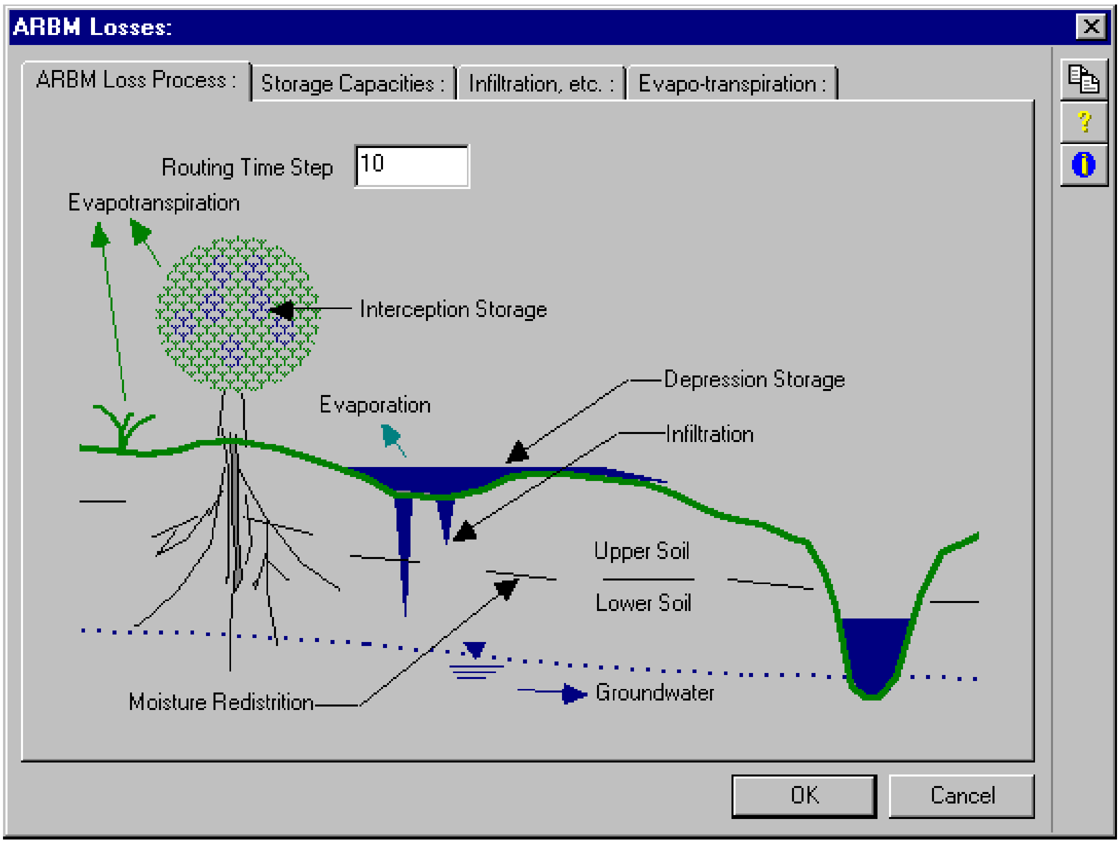
To utilize this module additional data describing such things as sorptivity, hydraulic conductivity, upper and lower soil storage capacities, soil moisture redistribution, groundwater runoff, and catchment drying are required.

The sensitivity of various parameters to the derived watershed runoff varies widely. Thus, a sensitivity analysis should almost always be performed to assess the critical parameters involved in the catchment calibration.

In using this loss module in an event mode, it is still necessary to provide soil moisture starting conditions prior to a design event. To achieve this some knowledge of appropriate antecedent conditions before the typical design event is required. If this information is not readily available then several values should be chosen and a sensitivity analysis carried out.

A diagrammatic representation of the LOSS Module is shown in the figure below.


Evaporation
Rain
Interception storage
Evapotranspiration
Depression storage
Impervious or pervious surface runoff
Infiltration function
Evapotranspiration
Upper soil zone storage
Laurenson's non-linear runoff routing model
Soil moisture redistribution function
Evapotranspiration
Lower soil zone storage
Lower soil zone drainage function
Groundwater storage
Groundwater discharge function
Streamflow



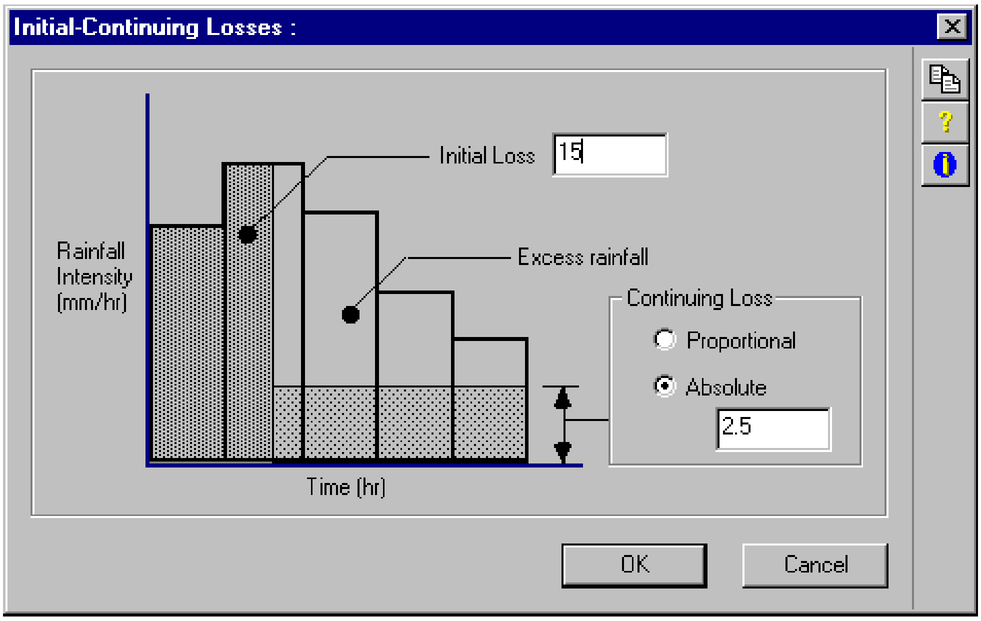
Storage Capacities

Infiltration etc

Evapotranspiration

Typical ARBM Parameters for Canberra Catchments

Initial/Continuing Losses



Initial/continuing database is a database of the initial and continuing loss rates employed in the initial/continuing loss model

This loss model is the most commonly used rainfall loss abstraction procedure for rainfall/runoff models. It requires an initial loss estimate that seeks to simulate initial catchment wetting when no runoff is produced, followed by a constant continuous loss rate expressed in mm/h to account for infiltration once the catchment is saturated.

Initial Loss: The initial loss estimate seeks to simulate initial catchment wetting when no runoff is produced, followed by a constant continuing loss rate expressed in mm/h to account for infiltration once the catchment is saturated.

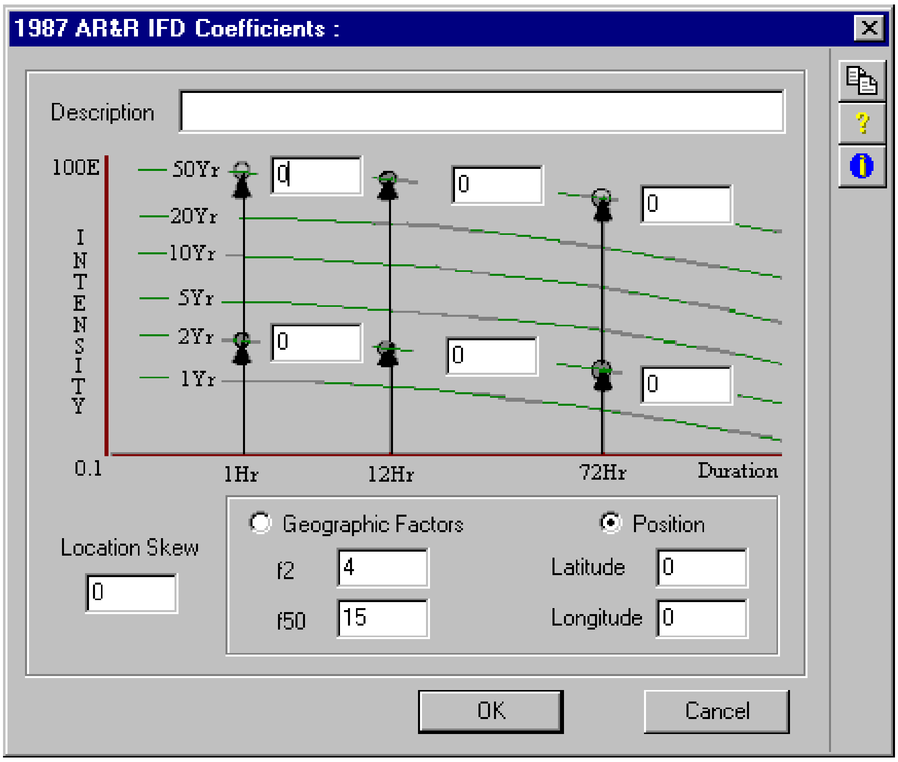
Typically recommended initial and continuing loss rates for Australian conditions include:

Type of Catchment Surface	Initial Loss (mm)	Continuous Loss (mm/hr)
Impervious Areas		
Roofs of houses, factories and commercial buildings, road surfaces, etc	1.5	0
Pervious Areas		
1) Sandy, open saturated soils	5.0 - 20*	10 - 25*
2) Loam soils	5.0 - 20*	3.0 - 10*
3) Clays, dense structured soils	5.0 - 20*	0.5 - 3.0*
4) Clay subject to high shrinkage and in a cracked state state at the start of rain	25 - 35*	4.0 - 6.0*
5) ARR (1977)	0 - 50	-
* Values taken from an unpublished report by Aitken (1974) based on various textbook values.		

Excess Rainfall: The excess rainfall is the net rainfall depth once all losses have been subtracted from the total rainfall.

Continuous Loss: The initial loss estimate seeks to simulate initial catchment wetting when no runoff is produced, followed by a constant continuing loss rate expressed in mm/hr to account for infiltration once the catchment is saturated. Alternatively a proportional continuing loss rate ranging between 0 and 1 of instantaneous rainfall may be input.

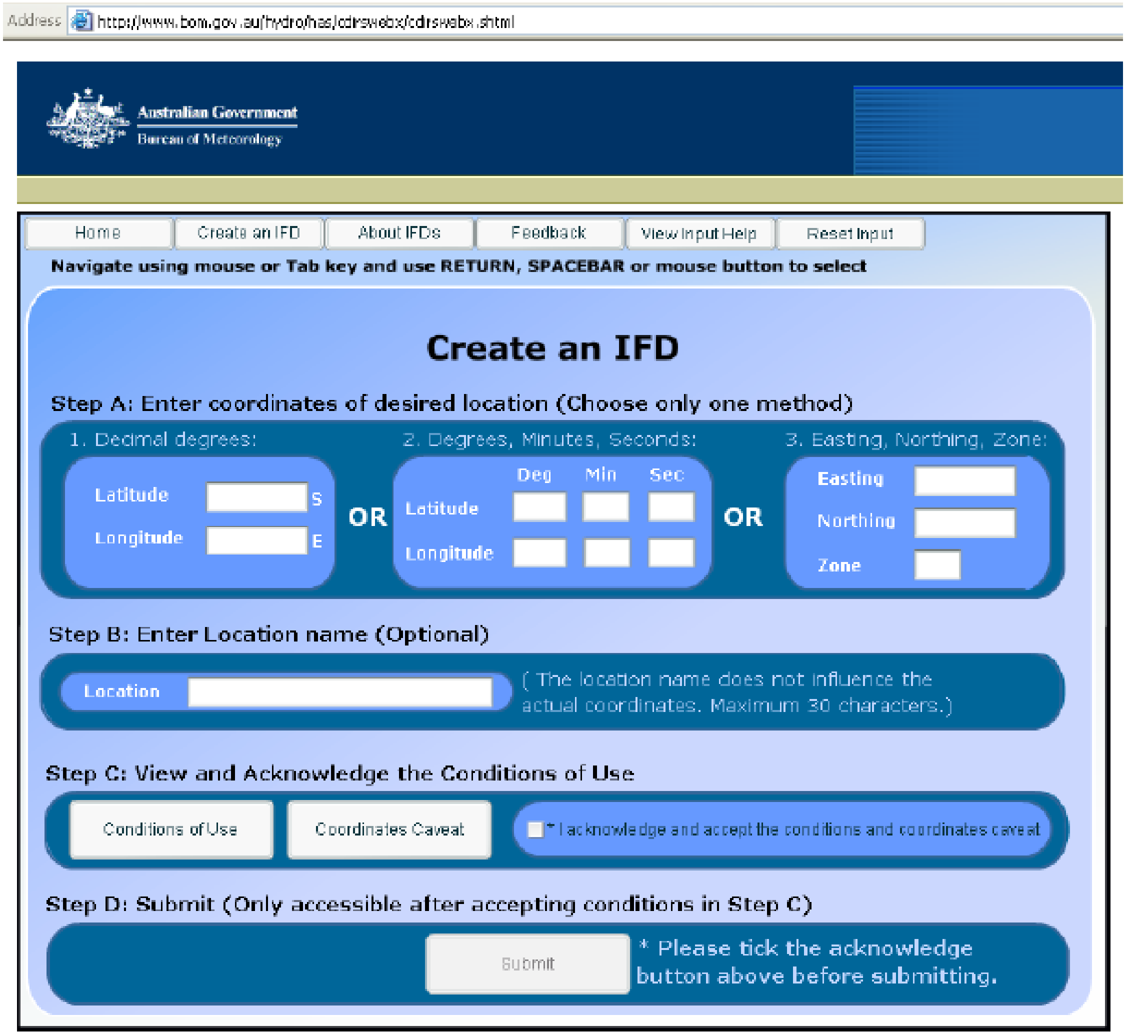
IFD Coefficients



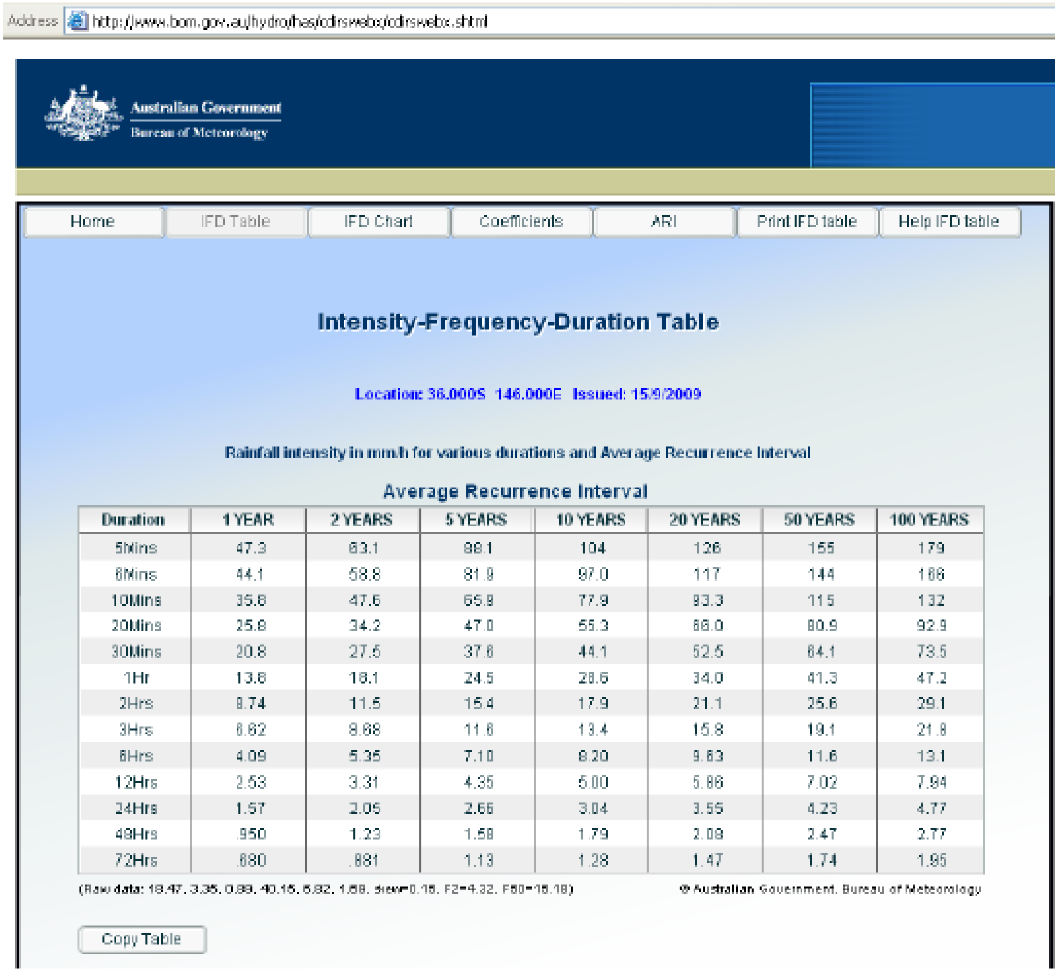
The user needs to specify the IFD (Intensity- Frequency-Duration) coefficients for 1, 12, and 72 hr intensities for 2 and 50 year return periods. These coefficients can be obtained from the Australian Rainfall and Runoff (ARR – 1987). The location Skew and Geographic Factors also need to be specified. Instead of Geographic Factors, the user can specify the Latitude and Longitude; in that case RAFTS will estimate the Geographic Factors.

The following web-link from BOM will be very useful to get IFD tables/values/charts:

http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml



The user can specify the Latitude and Longitude of the area, and can obtain the IFD details.



Address http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml

Australian Government
Bureau of Meteorology

Home | IFD Table | IFD Chart | Coefficients | ARI | Print IFD table | Help IFD table

Intensity-Frequency-Duration Table

Location: 36.000S 146.000E Issued: 15/9/2009

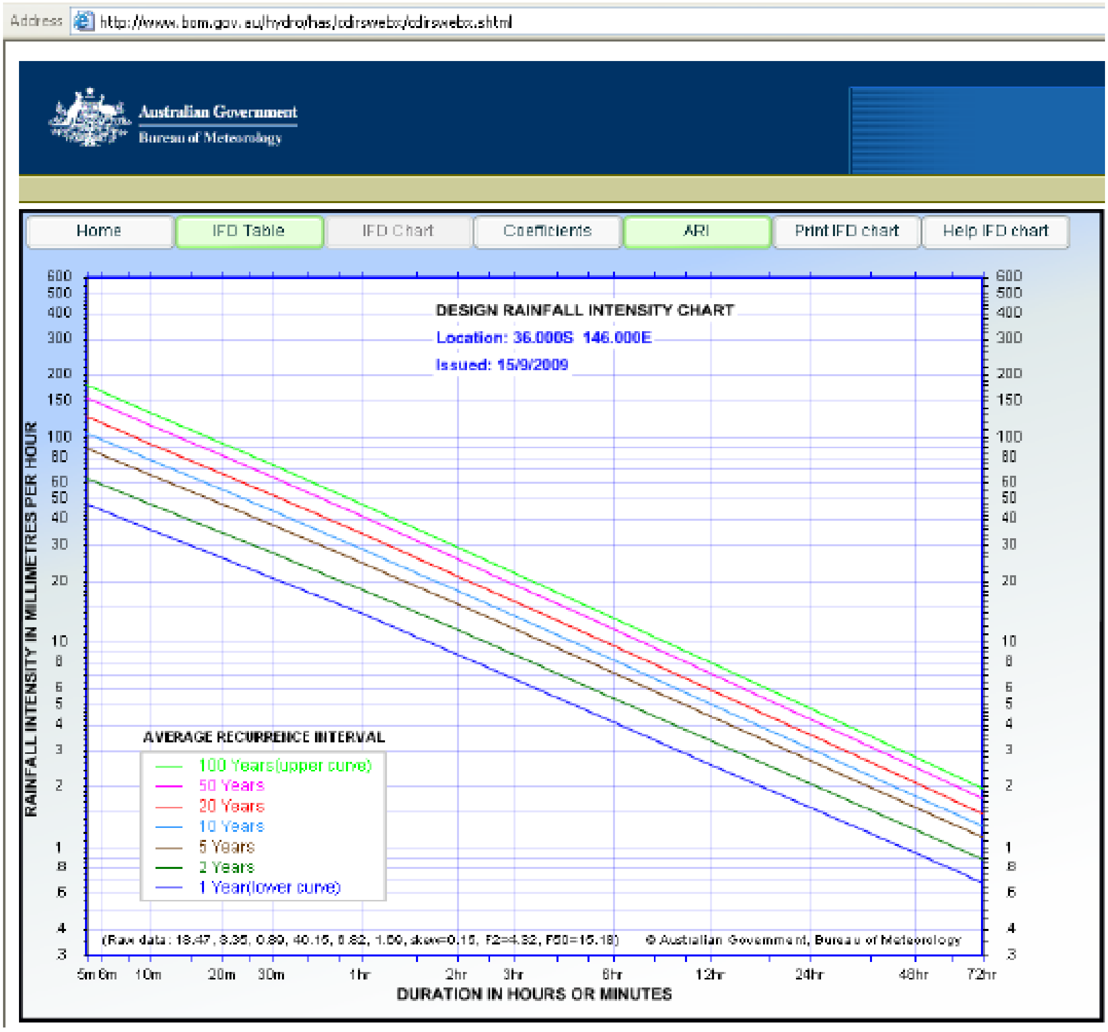
Rainfall intensity in mm/h for various durations and Average Recurrence Interval

Average Recurrence Interval

Duration	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
5Mins	47.3	63.1	88.1	104	126	155	179
6Mins	44.1	58.8	81.9	97.0	117	144	166
10Mins	35.8	47.6	65.9	77.9	93.3	115	132
20Mins	25.8	34.2	47.0	55.3	66.0	80.9	92.9
30Mins	20.8	27.5	37.6	44.1	52.5	64.1	73.5
1Hr	13.8	18.1	24.5	28.6	34.0	41.3	47.2
2Hrs	8.74	11.5	15.4	17.9	21.1	25.6	29.1
3Hrs	6.62	8.68	11.6	13.4	15.8	19.1	21.8
6Hrs	4.09	5.35	7.10	8.20	9.63	11.6	13.1
12Hrs	2.53	3.31	4.35	5.00	5.86	7.02	7.94
24Hrs	1.57	2.05	2.66	3.04	3.55	4.23	4.77
48Hrs	.950	1.23	1.58	1.79	2.08	2.47	2.77
72Hrs	.680	.881	1.13	1.28	1.47	1.74	1.95

(Raw data: 18.47, 3.35, 0.89, 40.15, 6.82, 1.68, skew=0.15, F2=4.32, F50=15.18)

Copy Table


Address http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml
Australian Government
Bureau of Meteorology
Home
IFD Table
IFD Chart
Coefficients
ARI
Print IFD chart
Help IFD chart
DESIGN RAINFALL INTENSITY CHART
Location: 36.000S 146.000E
Issued: 15/9/2009
RAINFALL INTENSITY IN MILLIMETRES PER HOUR
AVERAGE RECURRENCE INTERVAL
100 Years(upper curve)
50 Years
20 Years
10 Years
5 Years
2 Years
1 Year(lower curve)
(Raw data: 18.47, 3.35, 0.89, 40.15, 6.82, 1.50, skew=0.15, F2=4.32, F50=15.18)
© Australian Government, Bureau of Meteorology
DURATION IN HOURS OR MINUTES

Polynomial Coefficients Table

Location: 36.000S 146.000E Issued: 15/9/2009

List of coefficients to equations of the form

$\log_e(I) = A + B \times (\log_e(T)) + C \times (\log_e(T))^2 + D \times (\log_e(T))^3 + E \times (\log_e(T))^4 + F \times (\log_e(T))^5 + G \times (\log_e(T))^6$

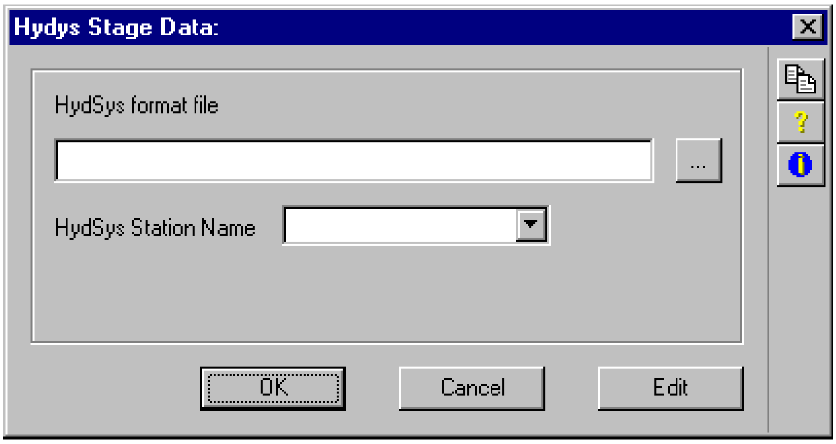
T = Time in hours and I = Intensity in millimetres per hour

YEARS	A	B	C	D	E	F	G
1	2.8215906143	-6.2912387E-1	-4.3837443E-2	8.2831597E-3	1.2928572E-3	-2.9102262E-4	-2.9294850E-5
2	2.8971168995	-6.3445657E-1	-4.3254580E-2	8.8720201E-3	1.1483849E-3	-3.5810770E-4	-1.3907874E-5
5	3.200056076	-6.4788860E-1	-4.2109620E-2	9.4072968E-3	8.9124340E-4	-4.0946269E-4	2.3651410E-6
10	3.3536436558	-6.5592062E-1	-4.0850401E-2	1.0230470E-2	5.9376650E-4	-4.8816515E-4	2.3629851E-5
20	3.5250587463	-6.6103178E-1	-4.1203648E-2	9.9259038E-3	7.4836010E-4	-4.4396642E-4	8.0779780E-6
50	3.7208559513	-6.6732746E-1	-4.0755354E-2	9.6912626E-3	7.0989840E-4	-4.0937107E-4	3.8494500E-5
100	3.853733778	-6.7171160E-1	-4.0171079E-2	9.7040720E-3	5.9575570E-4	-4.0613118E-4	7.2932610E-6

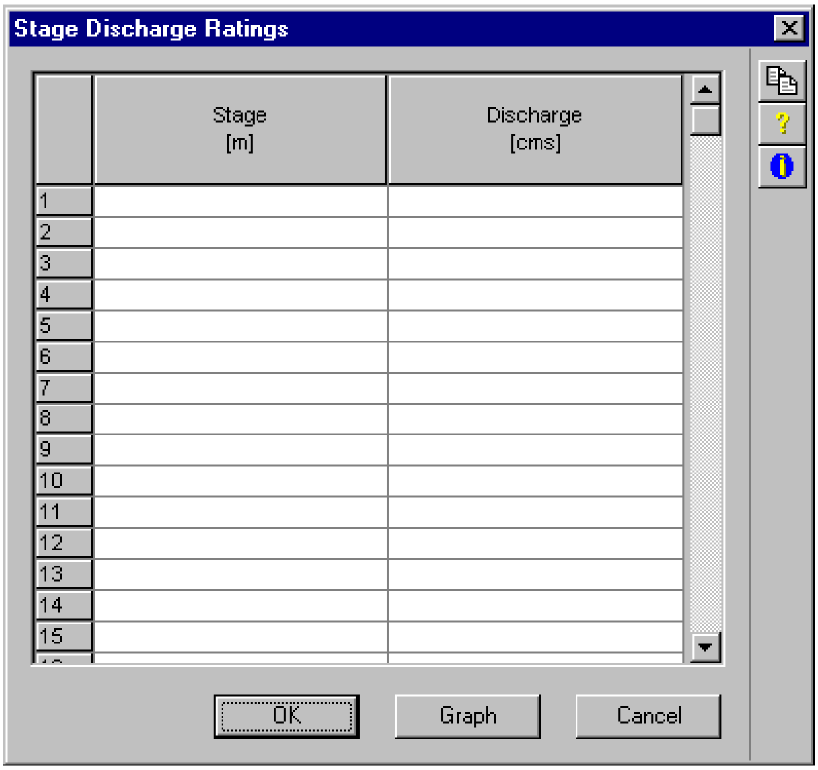
(Raw data: 18.47, 3.35, 0.89, 40.15, 8.82, 1.89, skew=0.15, F2=4.32, F50=15.18)

© Australian Government, Bureau of Meteorology

Prophet Stage Data



Stage/Discharge Data



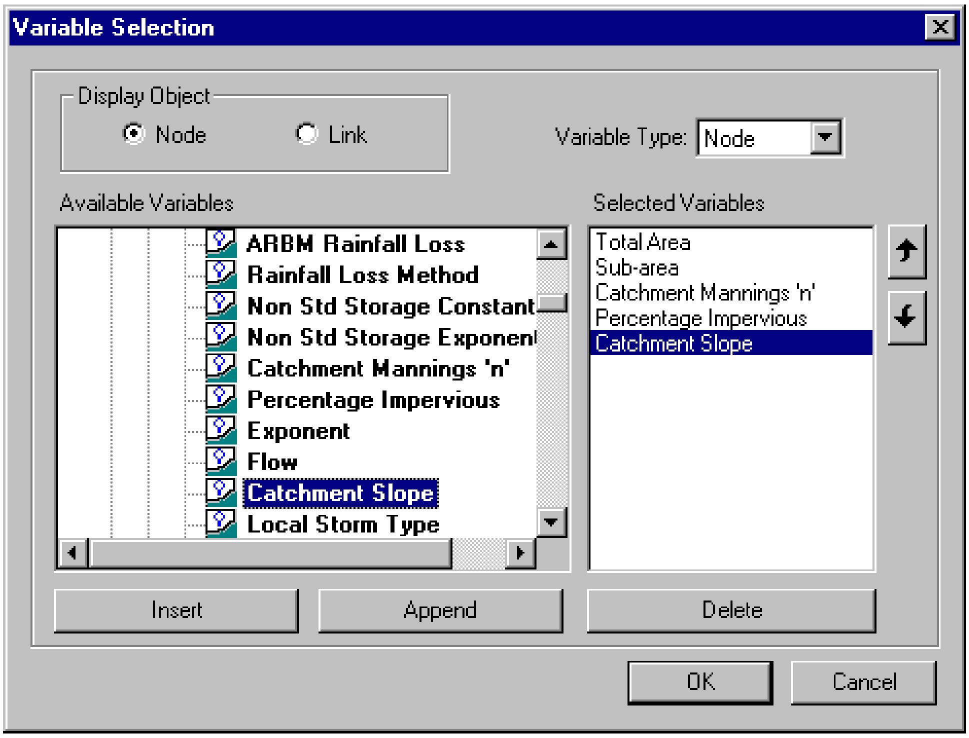
Stage vs discharge curves can be added to this global database and can be assigned to the nodes as gauged hydrographs.

XP Tables

XP-Tables allow the user to create a spreadsheet for data entry and manipulation in the model. The XP-Tables view is used to generate and manipulate data quickly and easily in the model. This format can be used to view results and create networks.

XP Tables can be launched by the following ways:

- Global database
- From the main window by selecting the XP Tables tool from the Results
- Pressing F2 button of the keyboard
- Pressing XP Tables tool in the main window



New: Press this button to add a new table.

Delete: This button is to delete the existing table

Edit: To edit the newly added or existing table

Rename: To rename the existing/newly added table

Duplicate: To duplicate any table

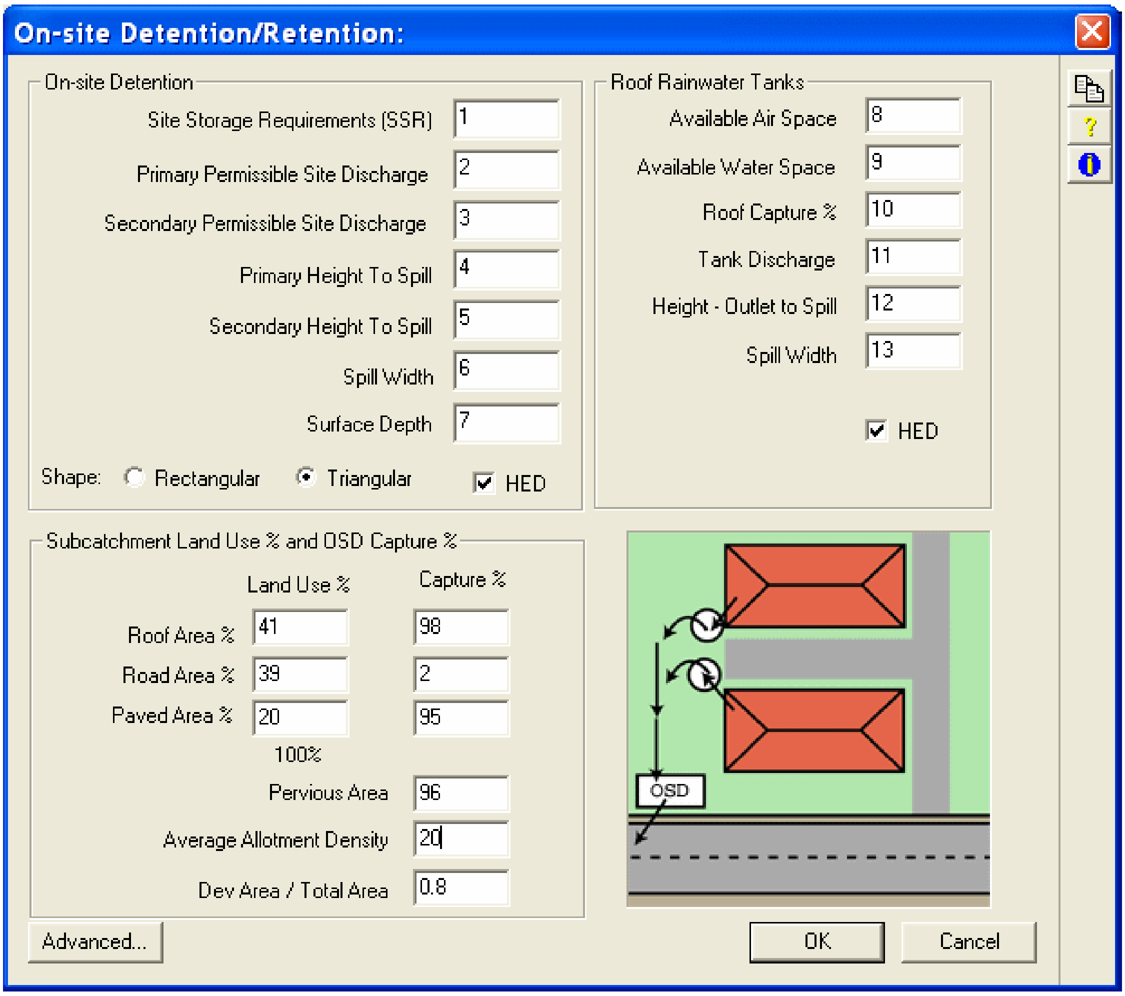
Display Object: Display object can be either node or link

Insert: To insert the selected variable

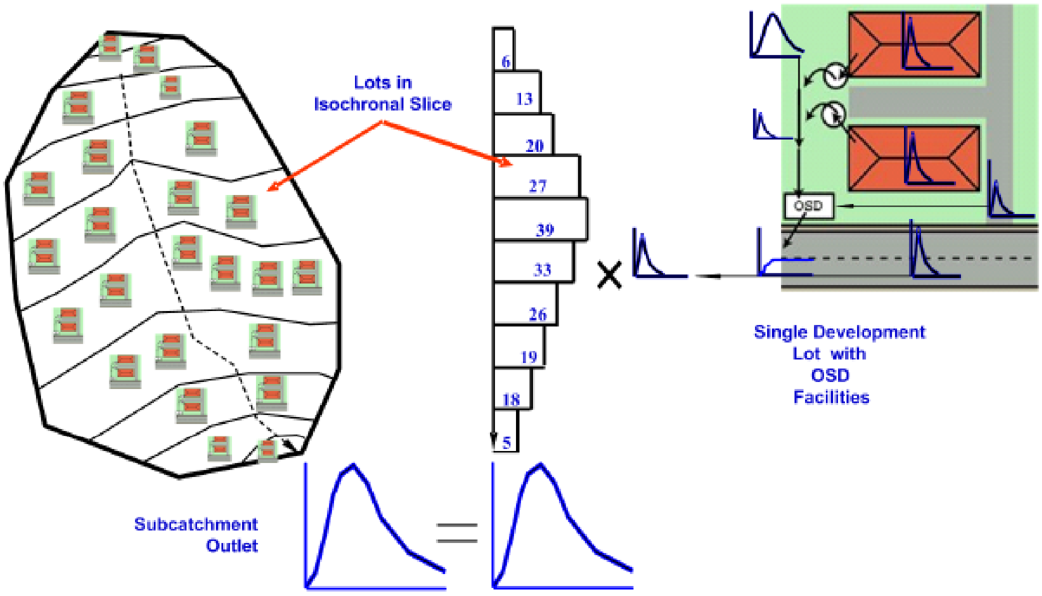
Append: To append the selected variable

Delete: To delete the selected/appended variable

Onsite Detention/Retention - Dialog



Data for rainwater tanks when used as an OSD device are required on a per lot basis. The accumulative water tank affect on the total sub-catchment discharge is derived by multiplying the single allotment device/s by the total sub-catchment area × the dev Area/Total Area ratio × the Average Allotment Density.



Descriptions of the field contents are given in the table below.

Onsite detention Site Storage Requirements Primary Permissible Site Discharge Secondary Permissible Site Discharge Primary Height to Spill Secondary Height to Spill Spill Width Shape HED	**Roof Rainwater Tanks** Available Air Space Available Water Space Roof Capture Tank Discharge Height - Outlet to Spill Spill Width HED
Subcatchment Land Use % and OSD Capture % Previous Area Average Allotment Density Dev Area/Total Area	

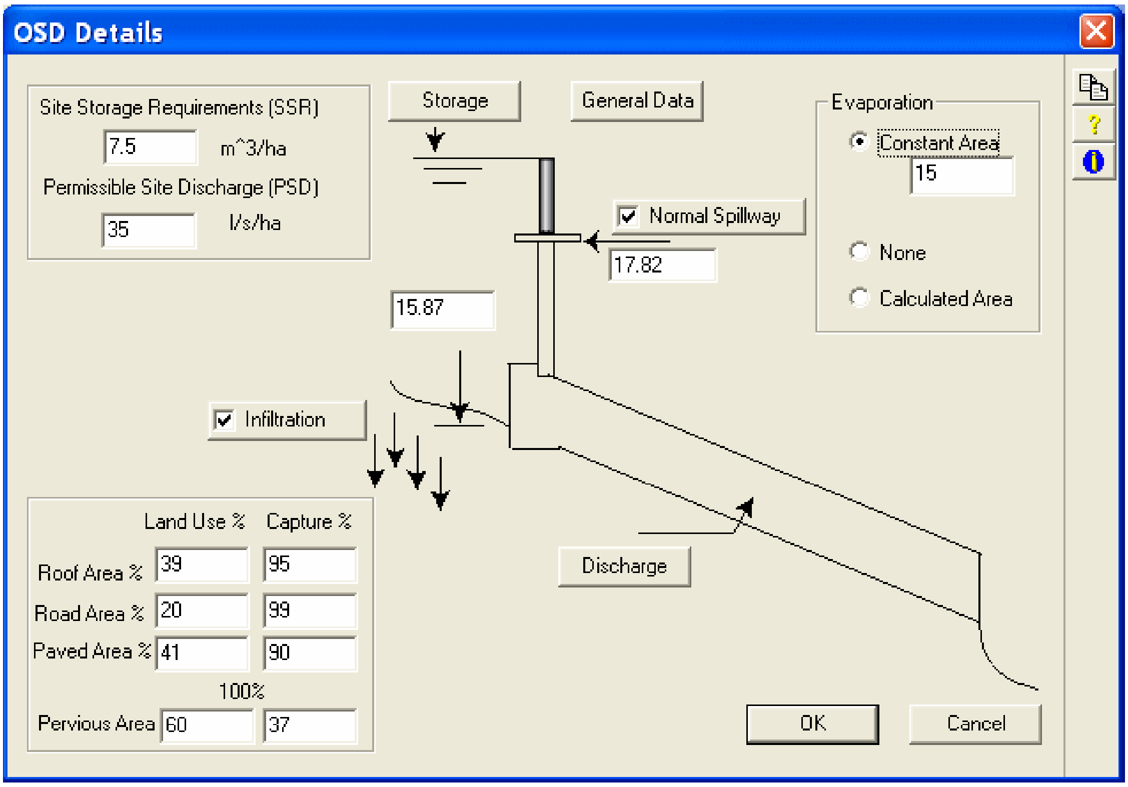
Advanced

Onsite Detention/Retention - General

Detention/Retention Storage Classification

Typical OSD Storage Facilities

OSD Details



Site Storage Requirement

Permissible Site Discharge

Storage

General Data

Normal Spillway

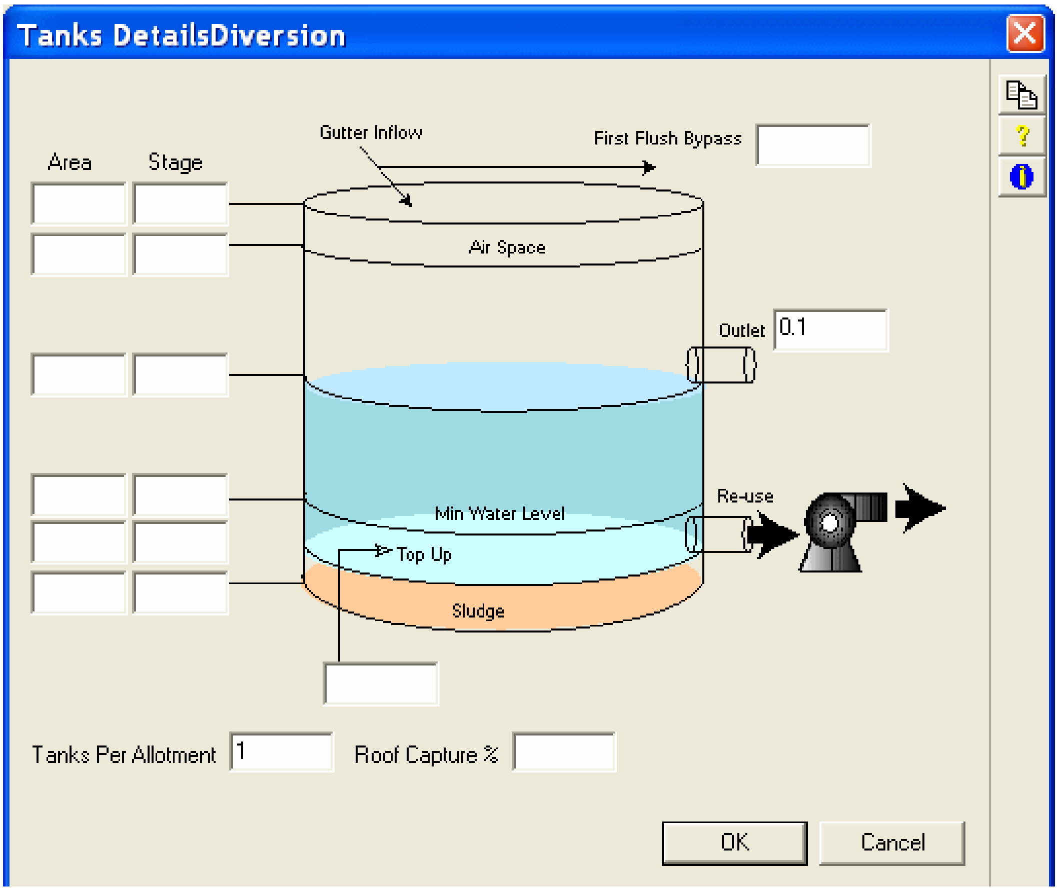
Evaporation

Infiltration

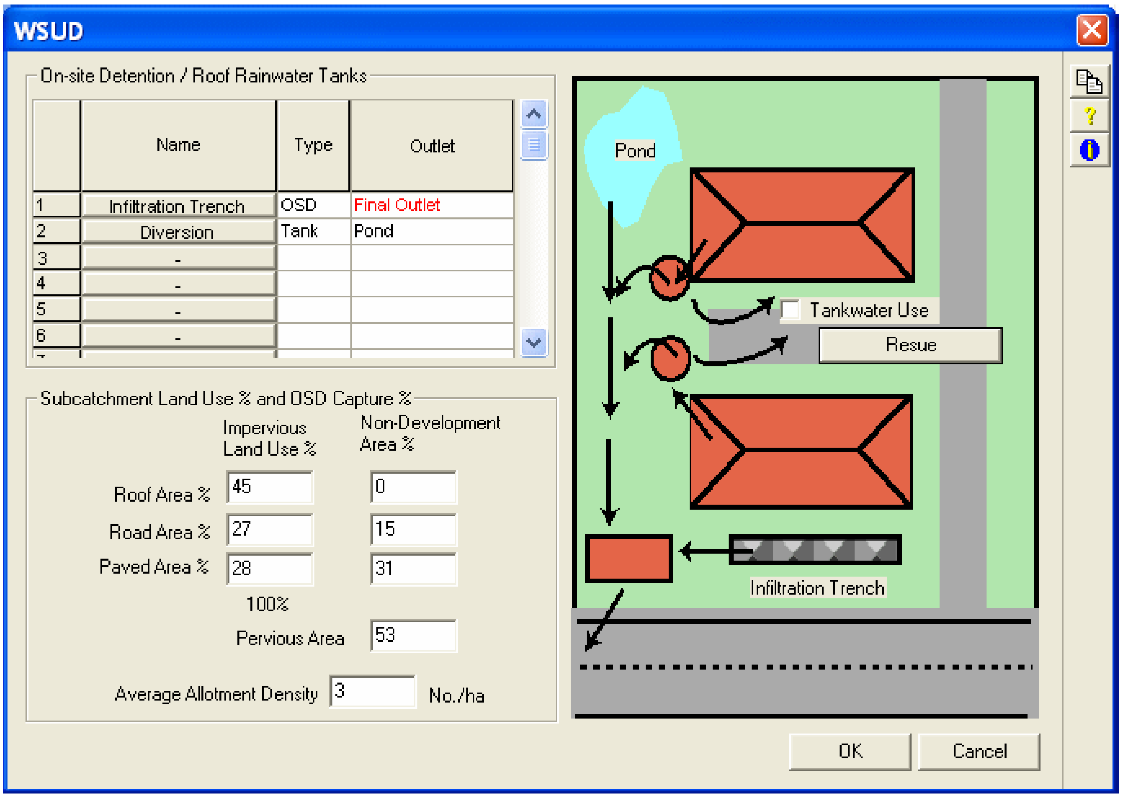
Discharge

Landuse%

Tank Detail



Water Sensitive Urban Design


WSUD
On-site Detention / Roof Rainwater Tanks
Name
Type
Outlet
1 Infiltration Trench OSD Final Outlet
2 Diversion Tank Pond
3 -
4 -
5 -
6 -
Subcatchment Land Use % and OSD Capture %
Impervious Land Use %
Non-Development Area %
Roof Area % 45 0
Road Area % 27 15
Paved Area % 28 31
100%
Pervious Area 53
Average Allotment Density 3 No./ha
Pond
Tankwater Use
Resue
Infiltration Trench
OK
Cancel

12 - PMP

PMP

Probable Maximum Precipitation (PMP) is defined as the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of year (World Meteorological Organization – 1986).

PMP has been used to estimate the Probable Maximum Flood (PMF) for catchments, which is essential for designing hydrological structures such as dam-spillways etc.

Generalized methods for estimating PMPs have been developed and introduced for different parts of Australia from mid- 1970s onwards. The generalized methods available for Australia are:

GSDM (Generalized Short Duration Method)
GSAM (Generalized Southeast Australia Method
GTSMR (Generalized Tropical Storm Method – Revised)

PMP Method Diagram

PMP Method Zones

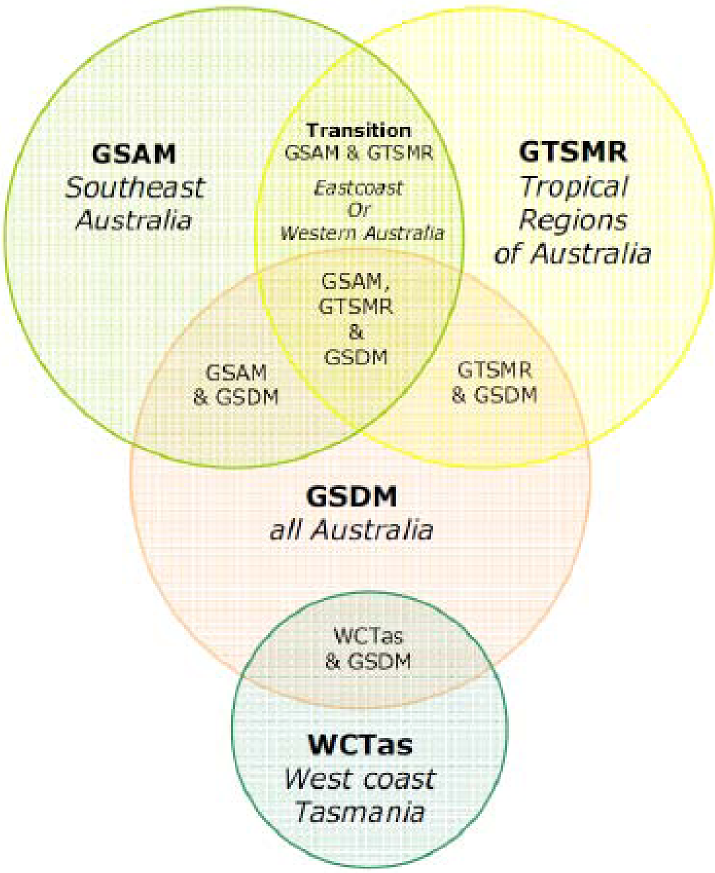
PMP Method Table

GSDM

GSAM

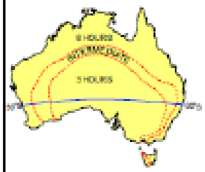
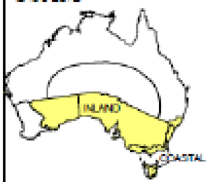
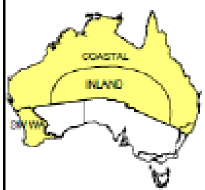
GTSMR

PMP Method Diagram



Source: Guidebook to the Estimation of Probable Maximum Precipitation: Generalised Southeast Australia Method. Bureau of Meteorology, Oct 2006.

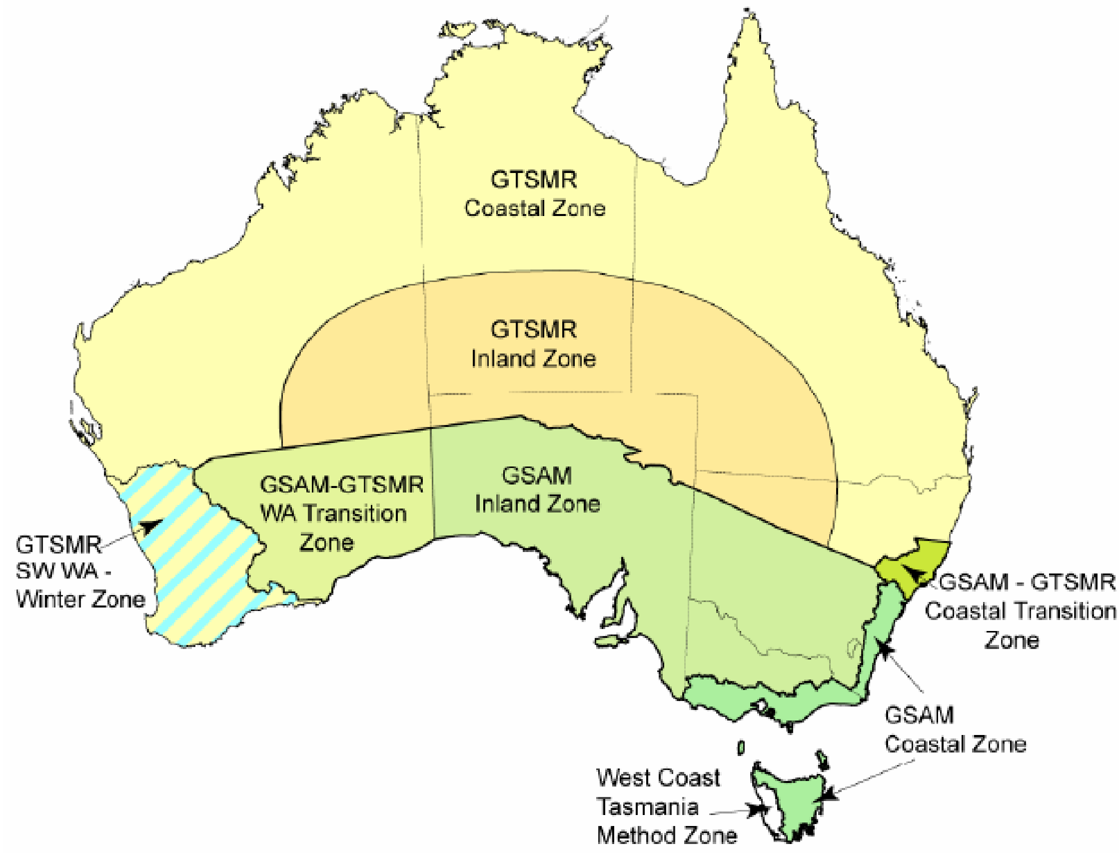
PMP Method Table

METHOD	AREA (KM²)	ZONE	LOCATION	SEASON	DURATION (HOURS)
GSDM	≤ 1000	3 Hour	Inland and south coast	annual	≤ 3
		Intermediate		annual	4 to 5
		6 Hour	West, north and east coast	annual	≤ 6
	≤ 500	3 Hour	south of 30°S	monthly	≤ 3
		Intermediate	south of 30°S	monthly	4 to 5
		6 Hour	south of 30°S	monthly	≤ 6
GSAM	1 to 1000	Inland	South Aust	annual	24[(1)] to 72
			Victoria	annual	24[(1)] to 72
			NSW	annual	24[(1)] to 96*
		Coastal	Tasmania	annual	24[(1)] to 72
			Victoria	annual	24[(1)] to 72*
			NSW	annual	24[(1)] to 96*
	1000 to 40,000	Inland	South Aust	annual	24* to 72*
			Victoria	annual	24* to 72*
			NSW	annual	24* to 96*
		Coastal	Tasmania	annual	24* to 72
			Victoria	annual	24* to 72*
			NSW	annual	24* to 96*
	> 40,000	Only issued on special request.			*One more (or one less) duration available on special request.
GTSMR	up to 150,000	Inland		annual	24[(2)] to 96
		Coastal		summer	24[(2)] to 120
			minus SW WA	winter	24[(2)] to 96
		SW WA	SW WA	winter	24[(2)] to 96
West Coast Tasmania	up to 3,000		Southwest Tasmania	annual	24 to 72

Source: Guidebook to the Estimation of Probable Maximum Precipitation: Generalised Southeast Australia Method. Bureau of Meteorology, Oct 2006.

GSAM 12-hour estimates are provided for catchments of area less than 1000 km² by interpolating between the GSDM and GSAM estimates. GTSMR 12-hour estimates are provided for all catchments by interpolating between zero and the 24-hour GTSMR estimate or, for catchments of area less than 1000 km², between the GSDM and GTSMR estimates. Transition zones exist between the GTSMR and GSAM zones (i) on the NSW coast and (ii) west of the WA-SA border to the end of the GSAM zone. In these regions, estimates made using both methods are provided; the one generating the larger PMPDF/PMF is recommended.

PMP Method Zones



Source: Guidebook to the Estimation of Probable Maximum Precipitation: Generalised Southeast Australia Method. Bureau of Meteorology, Oct 2006.

GSDM

$$PMP = (S * D_S + R * D_R) * MAF * EAF$$

Where:

S, R areally weighted terrain factor for the catchment. Smooth (S) + Rough (R) =1

D_S, D_R are initial rainfall depths for the smooth (D_S) and rough (D_R) terrain categories, which are read from the DDA curves

MAF, EAF are Moisture Adjustment Factors and Elevation Adjustment Factors

Terrain Category

Depth-Duration-Area Curves of Short Duration Rainfall (DDA Curves)

Elevation Adjustment Factor for Catchments

Moisture Adjustment Factor for catchments

GSAM

The revised GSAM (Generalized Southeast Australia Method) to estimate PMP:

1) Choosing the Correct Zone
2) Obtaining Raw Depths
3) Catchment Adjustment Factors
4) Preliminary GSAM PMP Depths
5) Final GSAM PMP Depths

GTSMR

The revised GSTMR (Generalized Tropical Storm Method) to estimate PMP:

1) Choosing the Correct Zone
2) Obtaining Raw Depths
3) Catchment Adjustment Factors
4) Preliminary GTSMR PMP Depths
5) Final GTSMR PMP Depths

13 - XP System

XP SYSTEM CAPABILITIES

The user is given continual guidance and assistance during data entry. For parameters that are difficult to estimate the user may be advised of literature to aid in selecting a value, or an explanation of a parameter and some proposed values may be shown on the screen through the use of on-line help. If there are other ways to pick the value typically, if the parameter is a function of other variables, the equation is shown to the user.

The user interface is intelligent and offers expert system capabilities based on the knowledge of the software developers and experienced users. For example, as various graphical elements are connected to form a network, EXPERT filters the user's actions so that a network that is beyond the scope of the model is not created. The general philosophy is to trap any data problems at the highest possible level - at the point the users create the data.

In addition to the well-known and accepted benefits of input and output graphics the EXPERT environment provides the user with expert data checking facilities. In the case of XP-RatHGL these checks include:

Network Manipulation

Data Type

Data Range Checking

Relational Consistency Checking

NETWORK MANIPULATION

Knowledge based data filtering prevents the creation of an illegal network or modifications that would result in an illegal network. The network is checked to meet the following constraints:

- Number of incoming links not greater than 10.
- Number of outgoing links not greater than 1.
- Number of outgoing diversions not greater than 1.
- Maximum number of all incoming links including diversions not greater than 10.
- Maximum number of all outgoing links including diversions not greater than 2.
- Loops are not allowed.

DATA TYPE

Data entered via text items is checked against the data type expected for that item. If a number is expected then the text string entered is interpreted to see it follows the rules for numerical strings. For example, if an integer (whole number) is expected, then invalid characters such as non-digits, decimal points etc, are trapped and the data is not accepted.

Pure text strings or comments are accepted as entered.

The syntax for numerical strings follows the usual rules. Larger-magnitude numbers can be entered via exponential notation.

EXPERT indicates floating-point numerical items by adding a decimal point if you haven't already done so.

DATA RANGE CHECKING

As data is entered it is filtered on two levels:

- Data is checked to ensure it is within a "reasonable" range.

  eg. Subcatchment slope has a reasonable range of 0.5 to 30 percent. If data is outside the reasonable range a warning message is issued with the reasonable range indicated but the data is accepted.

- Data is checked to ensure it is within an absolute limit.

  eg. Subcatchment slope cannot be <0. If data is outside the absolute range an error message is issued with the valid range indicated and the data not accepted. Execution cannot continue unless a valid value is entered or "Cancel" is selected.

RELATIONAL CONSISTENCY CHECKING

After all the data has been entered and the user attempts to solve the networks the inter-relationship of all data is checked for consistency, again at two levels:

- Warning messages are generated for data outside reasonable constraints, but the network can still be solved, and
- Error messages are generated for data outside the absolute range and the network can not be solved until these are corrected.

The following list includes some of the relational checks made:

1. Nodes at top of branches must have catchment data.
2. Warning level checks for reasonable pipe slopes. The reasonable range is set to between 0.3% and 30%.
3. Relative inlet/outlet invert levels at the outlet node. Invert levels should decrease downstream.
4. Relative inlet/outlet pipe diameter warning level checks at node. Pipe sizes should increase downstream.
5. Maximum water surface levels must decrease downstream. This is trapped as an error.

14 - RAFTS Theory

Overview

xprafts is a non-linear runoff routing model used extensively throughout Australasia and South East Asia. xprafts is has been shown to work well on catchments ranging in size from a few square metres to thousands of square kilometres urban or rural. xprafts can model up to 2000 different nodes and each node can have a sub-catchment attached, as well as a storage basin.

xprafts uses the Laurenson non-linear runoff routing procedure to develop a stormwater runoff hydrograph from either an actual event (a recorded rainfall time series) or a design storm utilising Intensity-Frequency-Duration data together with dimensionless storm temporal patterns, as well as standard AR&R 1987 data (Institution of Engineers, Australia, 1987).

Three loss models may be employed to generate excess rainfall. They are (1) the initial/continuing, (2) the initial/proportional loss model and (3) the ARBM water balance model. A reservoir (pond) routing model allows routing of inflow hydrographs through a user-defined storage using the level pool routing procedure. Modelling of hydraulically interconnected basins and on-site detention facilities can also be performed.

Three levels of hydraulic routing are possible: (1) simple Manning's-based lagging in pipes and channels, (2) the Muskingum-Cunge procedure to route hydrographs through channel or river reaches, or (3) the transfer of hydrographs to the XP-EXTRAN HydroDynamic simulation model.

Hydrology

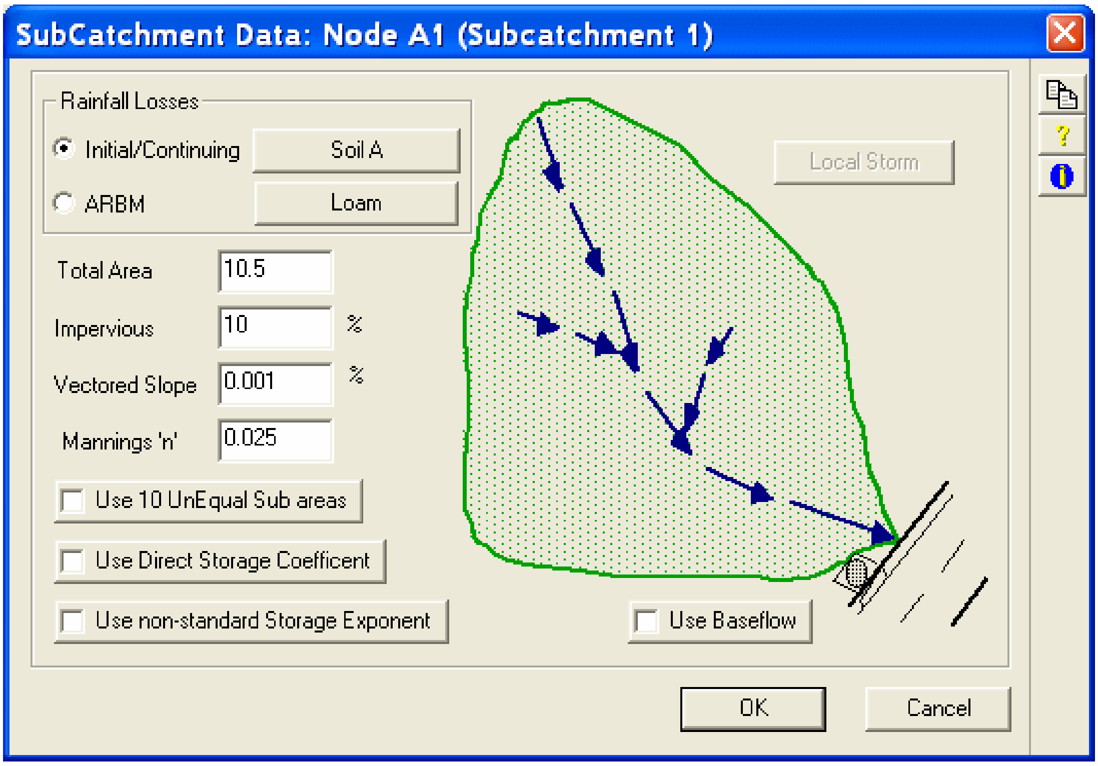
Hydrograph Generation

The Laurenson runoff routing procedure used in xprafts has the following advantages:

- It offers a model to simulate both rural and urban catchments.
- It allows for non-linear response from catchments over a large range of event magnitudes.
- It considers time-area and sub-catchment shape.
- It offers an efficient mathematical procedure for developing both rural, urban and mixed runoff hydrographs at any sub-catchment outlet.

The hydrological data requirements for XPRAFTS are :

- catchment area
- slope
- degree of urbanisation
- loss rates
- observed or design rainfall



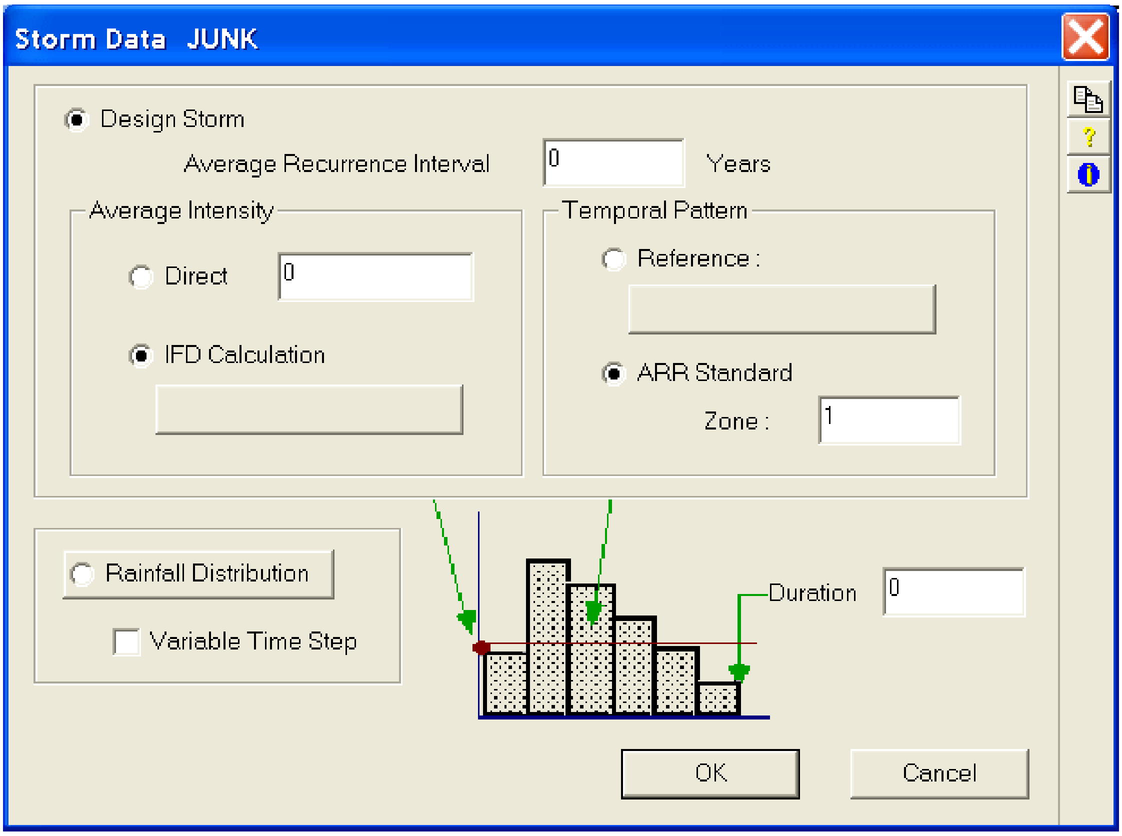
These data are used to compute the storage delay coefficient for each of the sub-catchments and hence to develop the non-linear runoff hydrograph. A default exponent is adopted, although the user may override this value with either a different non-linear exponent or a rating table of flow vs an exponent to define different degrees of catchment non-linear response.

Each sub-catchment is divided into 10 sub-areas. Each of the sub-areas is treated as a cascading non-linear storage obeying the relationship S=BavQ^(n+1), where n by default is set to -0.285 and B is computed from observed catchment event data or specified in terms of the catchment parameters. The rainfall is applied to each sub-area, an excess computed and the excess converted into an instantaneous inflow. This instantaneous flow is then routed through the sub-area storages to develop an individual sub-catchment outlet hydrograph.

Rainfall

Any local Intensity-Frequency-Duration information may be used to generate the hydrographs. Rainfall input can be of two types, either Design Rainfall or Historic Events. Design rainfall may be entered as a dimensionless temporal pattern with an average rainfall intensity, or in Australia may be extracted directly from Australian Rainfall and Runoff (Institution of Engineers, Australia, 1987).

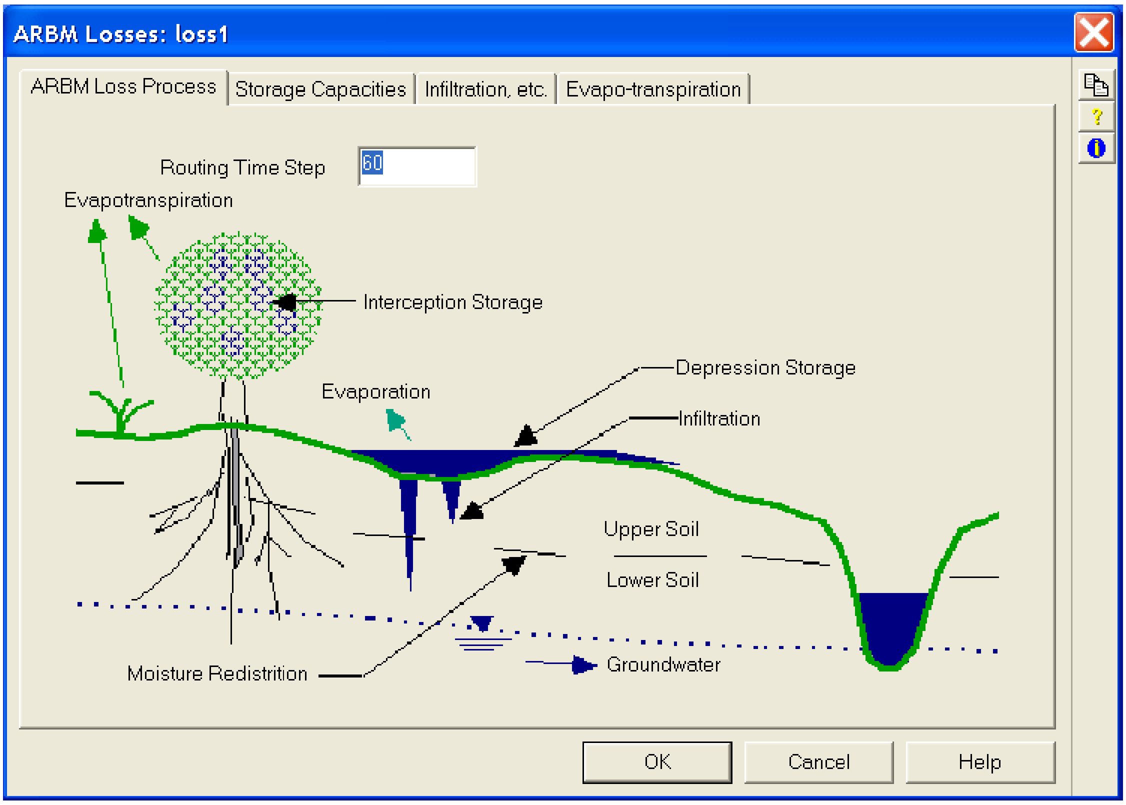
Historical events may be entered by the user in either fixed or variable time steps, allowing long lengths of record to be defined relatively easily. Alternatively the rainfall data may be read from an external rainfall file in either of two ASCII text formats. They are the HYDSYS file format or the XPX file format. Details of the HYDSYS format are provided in Appendix B together with the gauged flow and rainfall data collected as part of this study.



Loss Models

The rainfall excess may be computed using either of the following methods:

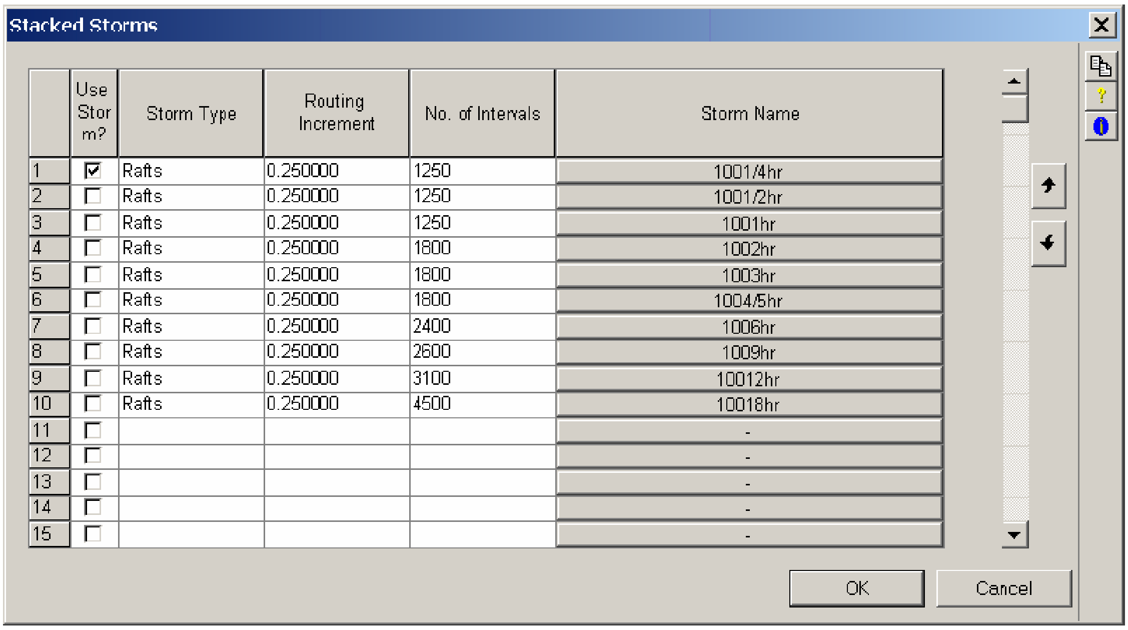
- Initial/Continuing: The initial depth of rainfall which is lost is specified along with a continuing rate of loss. For example 15 mm initial loss plus 2.5 mm/h of any further rainfall.
- Initial/Proportional: The initial depth of rainfall, that is lost, is specified along with a proportion of any further rain that will be lost. For example, 15 mm initial loss and 0.6 times any further rainfall.



- Australian Representative Basins Model (ARBM) Loss method: Infiltration parameters to suit Philip's infiltration equation using comprehensive ARBM algorithms are used to simulate catchment infiltration and subsequent rainfall excess for a particular rainfall sequence and catchment antecedent conditions. Data describing such things as the sorptivity, hydraulic conductivity, upper and lower soil storage capacities, soil moisture redistribution, groundwater runoff and catchment drying are required. Many of these data may be found from field measurements and this model allows for more realistic modelling of catchment response to storms, especially those with multiple bursts. A proportion of the outflow from the ARBM loss method may be redirected as base flow in a given reach.

Storms

Up to 10 storm events may be analysed in the same run and the results displayed on screen to determine quickly the critical duration for each location in the drainage system. Simulation runs of any length, from minutes to years, may be accommodated.



Stacked Storms

	Use Storm?	Storm Type	Routing Increment	No. of Intervals	Storm Name
1	☑	Rafts	0.250000	1250	1001/4hr
2	☐	Rafts	0.250000	1250	1001/2hr
3	☐	Rafts	0.250000	1250	1001hr
4	☐	Rafts	0.250000	1800	1002hr
5	☐	Rafts	0.250000	1800	1003hr
6	☐	Rafts	0.250000	1800	1004/5hr
7	☐	Rafts	0.250000	2400	1006hr
8	☐	Rafts	0.250000	2600	1009hr
9	☐	Rafts	0.250000	3100	10012hr
10	☐	Rafts	0.250000	4500	10018hr
11	☐				-
12	☐				-
13	☐				-
14	☐				-
15	☐				-

OK Cancel

Gauged data

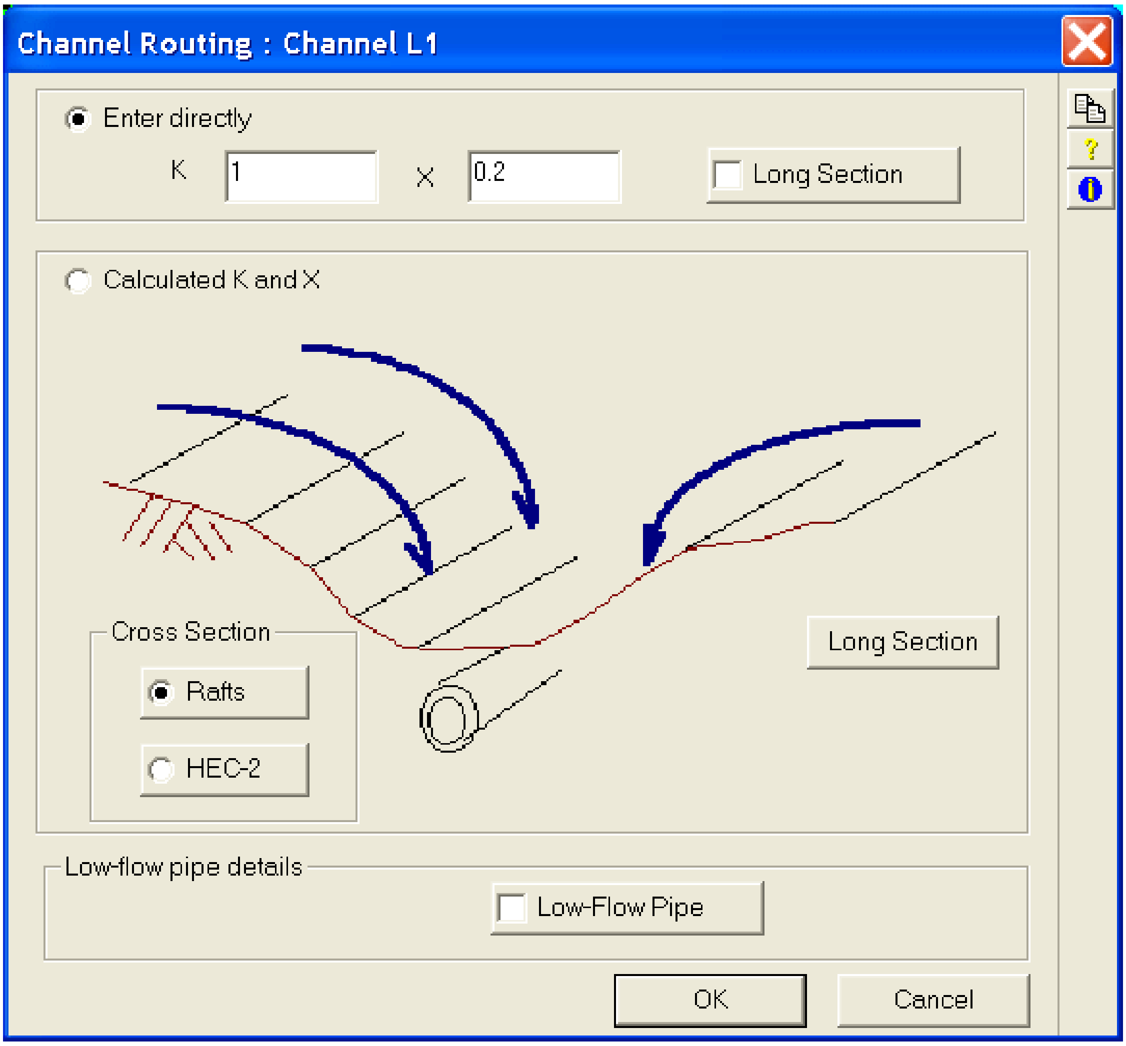
Gauged data may be entered by the user or read directly from an external file and compared to the computed hydrograph to assist in the calibration and verification of the drainage network simulation.

Hydraulics

Transporting Hydrographs

The hydrographs that have been developed at the individual nodes may be transported through the drainage system in three ways:

- Translation (Lagging). The user specifies the length of travel time from one node to the next and the hydrograph is translated on the time base by this length of time with no attenuation of peak flow. Appropriate values may be arrived at by estimating the velocity of flow and consequently the wave celerity, and knowing the length of travel.
- Pipe Flow. A pipe may be specified (or sized) to carry some or part of the flow with any flow in excess of pipe capacity travelling via the surface to either of two destination nodes. The travel time in this pipe may be computed or set to a fixed number of minutes.
- Channel Routing. A Channel/Stream may be defined using either compound trapezoidal channel or HEC-2 style arbitrary sections. (HEC-2 is the widely-used water surface profile computational program developed by the Hydrologic Engineering Center of the US Army Corps of Engineers.) The cross-section shape may be imported directly from an existing HEC-2 file. The Muskingum-Cunge method is used to route the flow through the channel with the consequent attenuation of the peak flow and delay of the hydrograph peak.
- Diversion Link. Any node may have a diversion link defined in addition to the normal link, which will divert some or all of the flow to an alternate destination node elsewhere in the drainage system.
- Pipe Design. Manning's equation is used to size the pipes to carry the peak discharge in the reach.



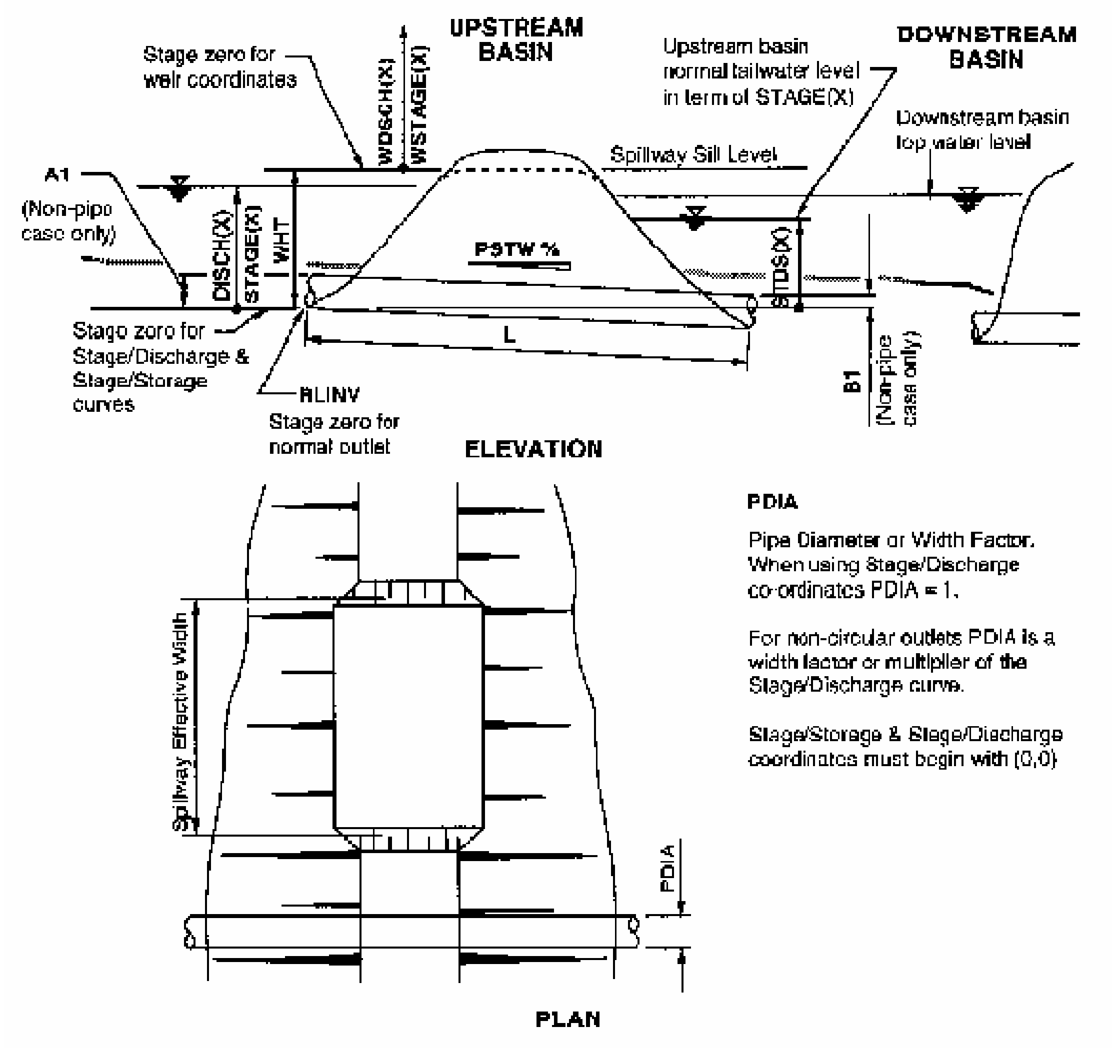
Hydrodynamic Modelling

The hydrographs generated in xprafts may be directly transferred to the XP-EXTRAN hydrodynamic simulation model as well as to the MIKE-11 unsteady flow open channel hydraulics model. Hydrographs may also be read back into another xprafts model.

Storage Basins

Any node in xprafts may be defined as a storage node. This storage may be quite small (a few cubic metres) or quite large (gigalitres), or any size in-between. On-line and off-line storages may be simulated and the storages may be hydraulically interconnected.

Puls' level pool routing technique is used to route the inflow hydrograph through the nominated storages. A stage storage relationship is defined for each of the storages. The outlet structures that may be handled include:



- circular pipe culverts
- rectangular box culverts
- broad crested weirs
- sharp crested weirs
- ogee weirs
- erodible weirs
- multi-level weirs
- high level outlets
- rating curve outlets
- evaporation
- infiltration

Optimisation methods are available to help design the basin. You may optimise the basin for a maximum discharge or for a maximum allowable storage.

Importing Data

Importing Data

Data may be imported from an ASCII text file in the XPX file format. This format allows the user to create new data and objects as well as update and add to existing XPRAFTS networks. This facility may be used to import information from GISs, FISs, CAD packages and other databases.

Plan drawings may be imported from virtually any CAD package or GIS to be used as a scaled base map.

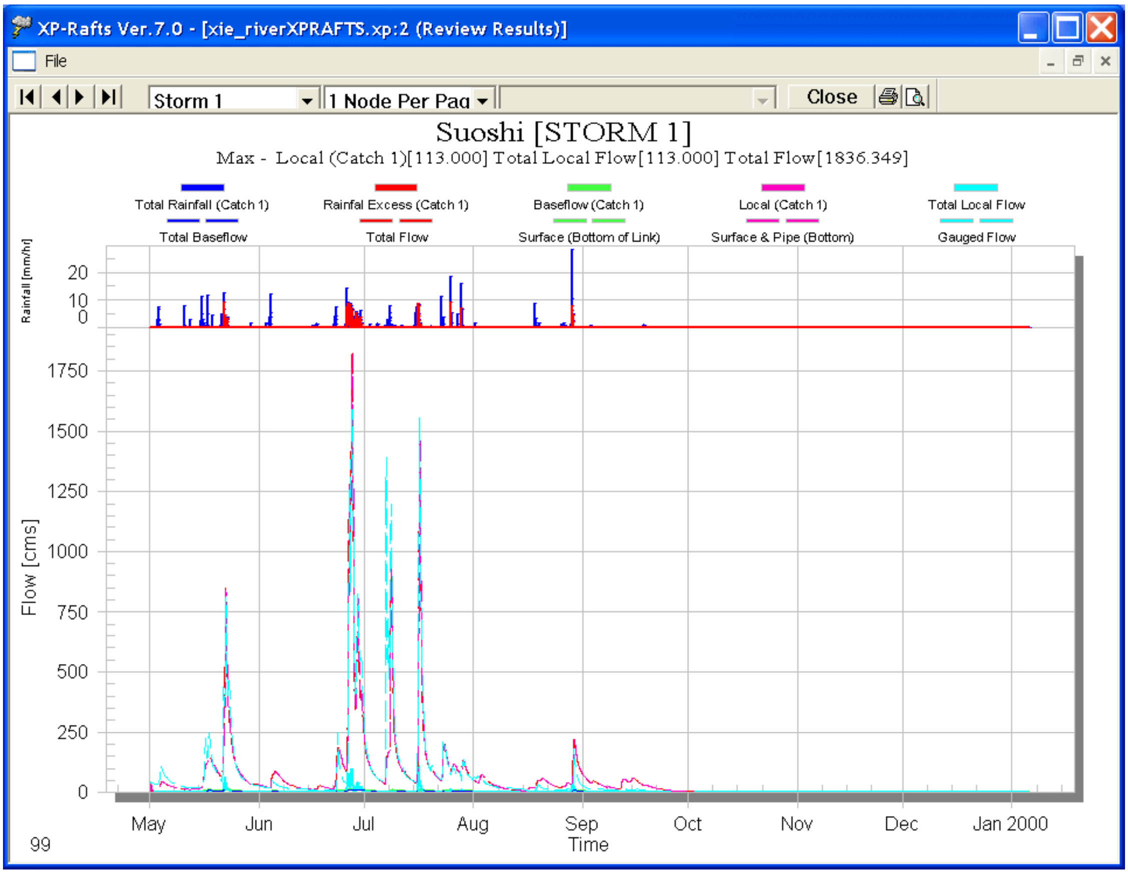
Output

Output

xprafts provides results and data in various forms. All graphical displays may be outputted to printers, plotters or to DXF files.

Graphical Output

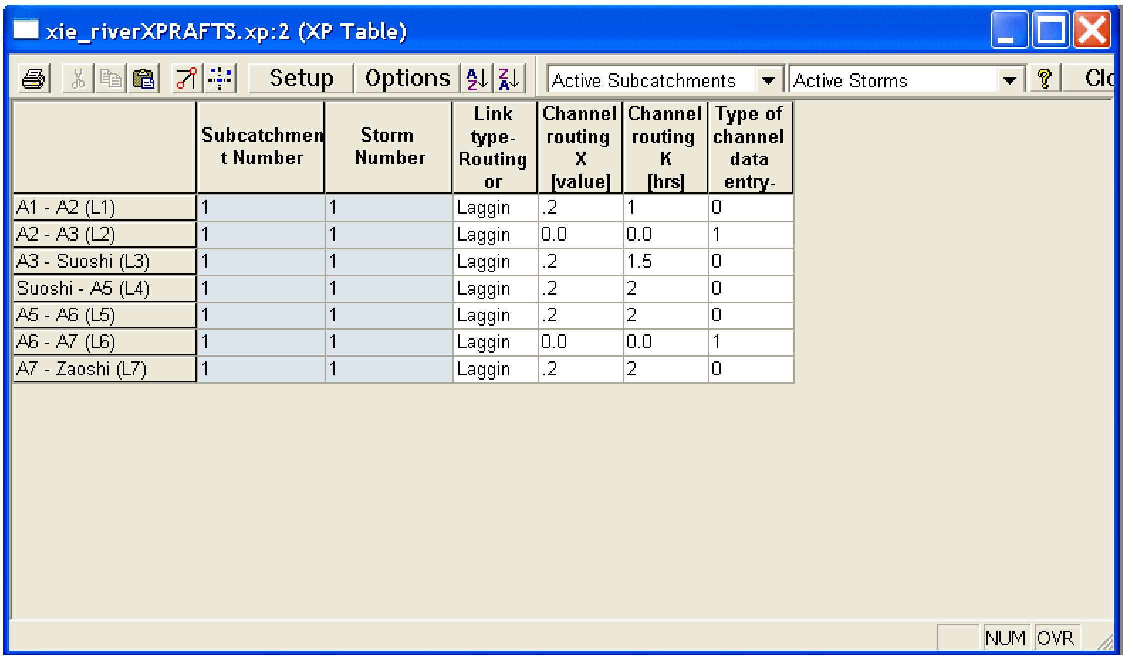
xprafts provides graphs of rainfall, rainfall excess, hydrographs including total and local components of the hydrographs. Stage history and storage history are also available for any pond or basin in the drainage system. The graphs for up to 16 locations may be displayed and printed or results exported to a comma-delimited ASCII text file for use in spreadsheets or databases.



Tabular Reports

Comprehensive tabular reports may be generated for both the hydrology and the hydraulic results and data.

In addition to the formatted tabular reports, an ASCII text output file is available with detailed information on both the hydrology and the hydraulic calculations.



	Subcatchment Number	Storm Number	Link type-Routing or	Channel routing X [value]	Channel routing K [hrs]	Type of channel data entry-
A1 - A2 (L1)	1	1	Laggin	.2	1	0
A2 - A3 (L2)	1	1	Laggin	0.0	0.0	1
A3 - Suoshi (L3)	1	1	Laggin	.2	1.5	0
Suoshi - A5 (L4)	1	1	Laggin	.2	2	0
A5 - A6 (L5)	1	1	Laggin	.2	2	0
A6 - A7 (L6)	1	1	Laggin	0.0	0.0	1
A7 - Zaoshi (L7)	1	1	Laggin	.2	2	0

Detailed Description of xprafts

General Model Structure

The following description is taken in part from the technical description manual for the xprafts software package co-developed by Goyen (1976, 1981, and 1991). The information provides a fairly detailed description of the various modules and procedures within that package that have been utilised in this research.

As the author was the developer of the xprafts software, the complete source code was obviously available to utilise, modify and build on throughout the current research .

In particular, the sub-catchment hydrograph development module was modified significantly to introduce the types of approaches proposed in Chapters 3, 6 and 7.

The existing overall structure of the xprafts software provided a very flexible workbench to test an array of process tree type procedures and to view their results.

Within the xprafts framework the workbench allowed the consideration of linear and non-linear responses, and a mixture of concentrated and distributed storages. The node link structure also allowed the consideration of separately-contributing surfaces with distinctly different infiltration and runoff responses.

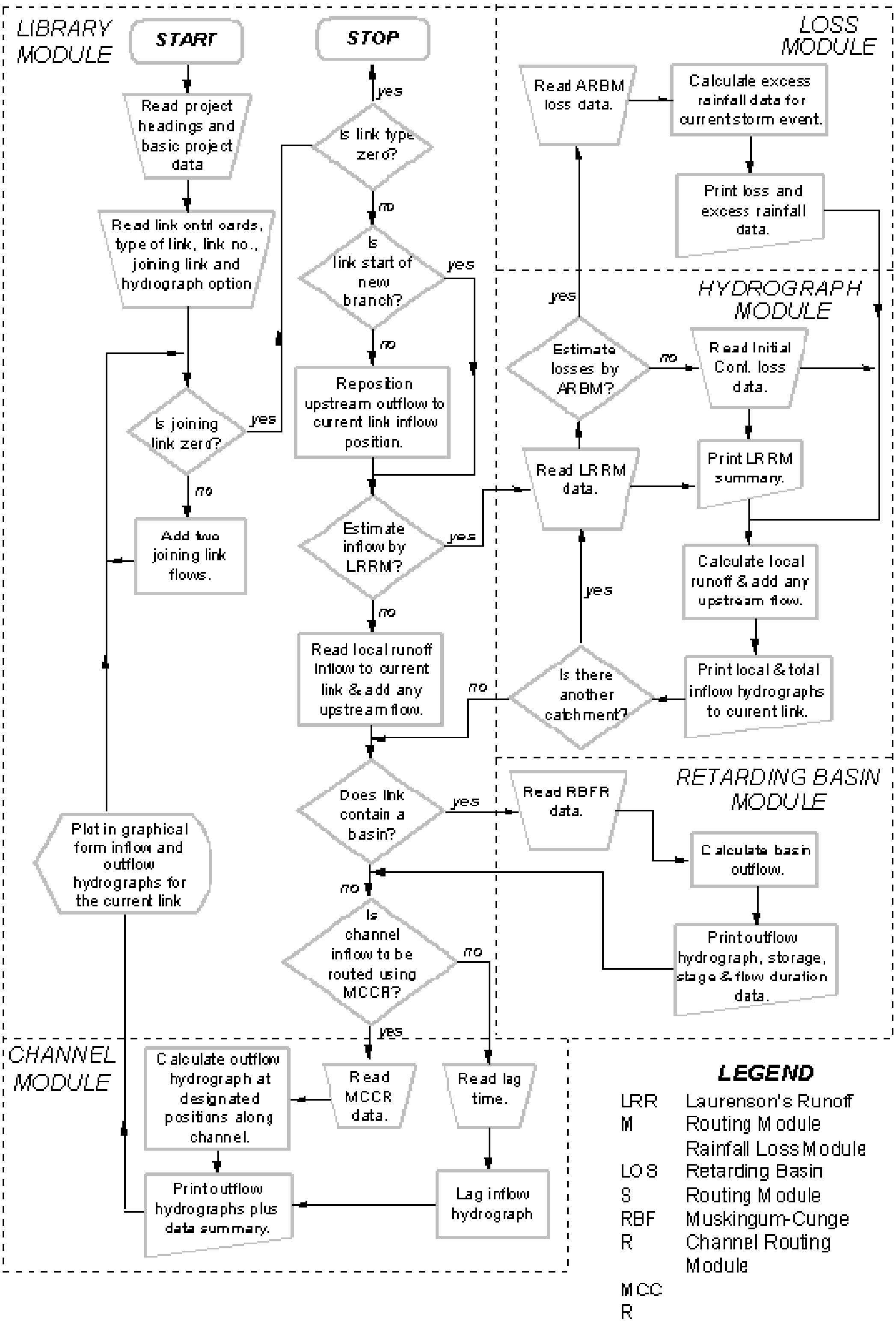
Program Organisation

xprafts is organised as a series of discrete modules each addressing a particular component of the rainfall/runoff routing process. The separate modules are called in a particular sequence according to the way that input data is coded.

The program currently consists of five modules:

1. a library module which manages the overall operation of the program and controls data, computation and output sequences,
2. a hydrograph-generation module which estimates a runoff hydrograph from either an actual rainfall event or a design storm using Laurenson's non-linear runoff routing method,
3. a loss model employing Philip's infiltration equations and the Australian Representative Basins Model (ARBM) to simulate both rural and urban excess rainfall,
4. a reservoir routing module which routes an inflow hydrograph through a retarding basin or storage using a level pool routing procedure. The module also handles hydraulically interconnected basins,
5. a river/channel routing module which routes a hydrograph along a channel using the Muskingum-Cunge procedure.

The following sections describe the library, hydrograph, retarding basin, loss and channel sections of xprafts in detail. This Figure describes the various program modules and how they are linked.



General Data Requirements

Data requirements for RAFTS are commensurate with the data availability and output requirements. The model is particularly flexible in its requirements and able to produce satisfactory results with minimum data input.

It would be prudent to state that provided access to a suitable micro-computer was favorable then it would be appropriate to employ RAFTS even for the most straight forward runoff estimate. The input data requirements and run time would be no more intensive than hand computations applying say the Rational Formula.

As more data is collected or becomes available on a catchment, input data can be upgraded to produce more appropriate results taking into account parameters such as gauged rainfall and runoff data, soil infiltration data, hydraulic characteristics, retention basin parameters, dynamic flood routing floodway and pipe systems, separate impervious and pervious overland flow routing etc.

Library Module (LIBM)

This module is responsible for all communication with the other modules and thereby controls the execution sequence of the project run. Most data however is called directly from the module concerned at the time of execution to save storage.

Information is directed to the correct module in the program by a series of control records located near the beginning of the data file.

In addition to the LIBM’s housekeeping and management role, it also performs all hydrograph summations, carries out basic data organization, produces hydrograph plots and prints output summaries.

Time Step Computations

All computations in xprafts are carried out in discrete time increments sequentially working from time zero through a rainfall event. The time increment is designated the routing increment and is expressed in decimal minutes. There are no absolute limits to its magnitude.

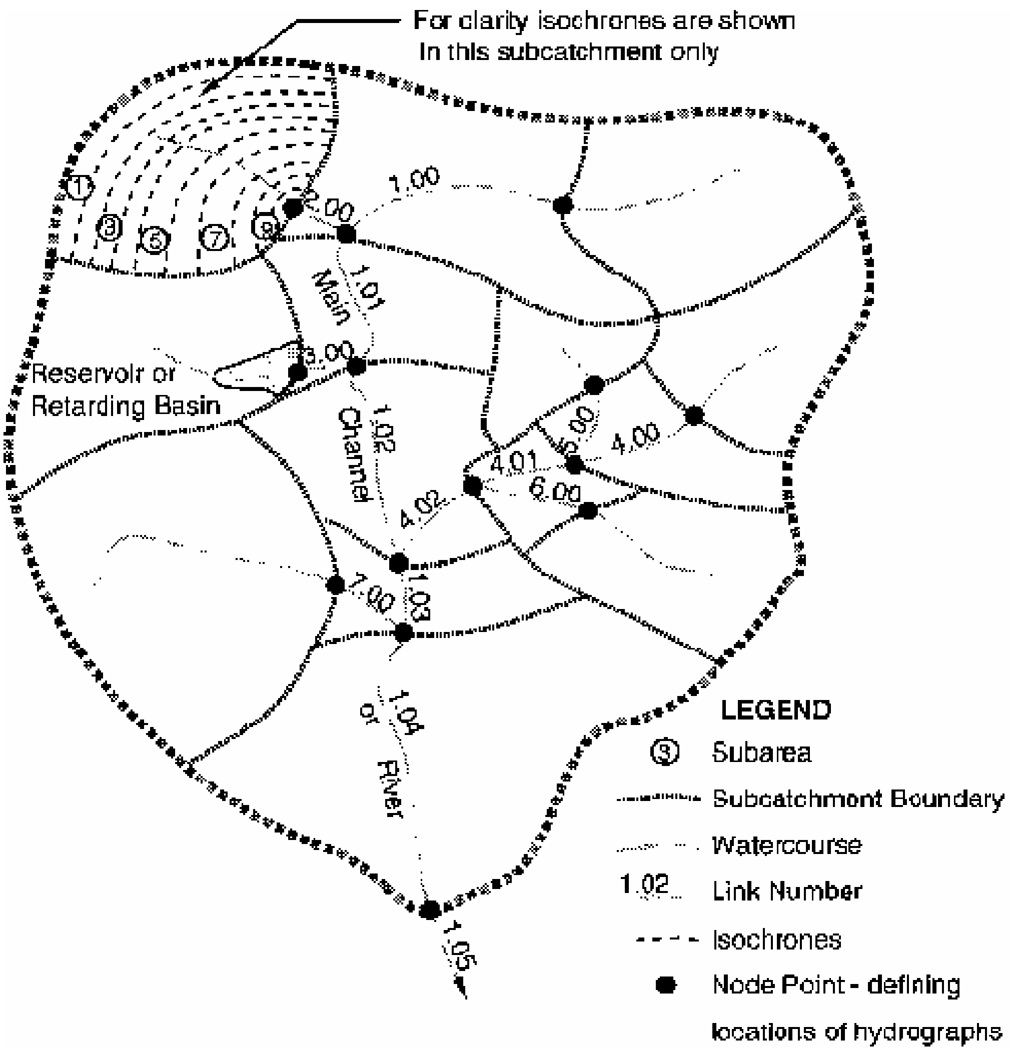
The selected routing increment should be the minimum needed to span enough of the expected runoff hydrograph to obtain the required information. In many instances this may not require the whole hydrograph to be developed. In some instances however, such as loss rate calibration, the full hydrograph recession may be required.

The current workbench software is limited to 2000 routing increments in any one pass. An additional requirement is that a routing increment should be wholly divisible into a partition of a rainfall temporal pattern to prevent the loss of a fraction of a rainfall in each increment. If this is neglected an appropriate warning message is generated. Additionally the routing increment should be no longer than the shortest link lag time.

Definition of Link

In its most basic form, a drainage network can consist of a single conduit, with or without a retarding basin at its head. This situation is defined as a single link. An input hydrograph is derived from a single sub-catchment immediately above each link.

The drainage system is usually made up of many such links combined to form a complete network where the individual catchments (links) become sub-catchments of the overall watershed. The Figure describes diagrammatically a link and the way in which individual links are joined to form a network.



Convergent and Divergent Links

xprafts currently allow both convergent and divergent link networks. The normal convergent system is displayed in the example shown in the figure above.

Divergent flows are handled by defining a link capacity for the sub-catchment in question followed by a separate link number to which overflows are directed.

The overflow stored in the separate link can either be removed from the network completely or can rejoin at a lower junction by normal linking procedures.

In addition, the user may set a fraction of the flow to be diverted once flow exceeds a threshold, through the use of a diversion link in xprafts.

Development of Catchment, Channel & Network Data

The main components of the catchment model are the sub-catchments, links and subareas defined in Definition of Link.

The arrangement, sequencing and number of individual elements is made entirely flexible to appropriately represent watershed components. Nodes representing the outlet of individual sub-catchments and links are described graphically within the user environment.

Catchment Area Representation

In general, the sub-catchments are established by dividing the main catchment into areas defined by tributaries and ridges. The link network connects these sub-catchments.

In the xprafts context, sub-catchments are usually drawn to points where flows are required, changes in topography occur, retarding basins are proposed, or at other locations where hydrographs are needed. Links are then constructed to join the sub-catchments.

The runoff from a sub-catchment flows into the top of a link. The minimum number of sub-catchments is not important as the outflow from each single sub-catchment should be correct in itself.

The division of the catchment should reflect the individual analysis of homogeneous sub-catchments. The degree of urbanisation, slope, ground cover and type, etc, should be reasonably uniform within each sub-catchment.

If distinct changes in urbanisation or other characteristics occur within sub-catchments then further subdivision should be considered to define differences in catchment storages and flow times.

The figure above shows the links joining the tributaries to the main stream as having real lengths. They can also have zero length, i.e. a dummy link. The lag down such a link would be zero. Dummy links with dummy sub-catchment areas (say 0 .01 ha) can be included to allow the generation of hydrographs at additional nodes in a network, particularly at junctions.

Treatment of Subareas

xprafts uses Laurenson's (1964) method to generate its hydrographs. Laurenson's model was directed at single catchments, or more particularly, the derivation of a single hydrograph at the outlet of a catchment. However, in the case of XPRAFTS the sub-catchments are divided into ten sub-areas.

Sub-areas are established by dividing each of the sub-catchments into ten areas defined between lines of equal travel time or isochrones.

xprafts uses Laurenson's model to derive separate sub-catchment inlet hydrographs. These hydrographs are then manipulated through the link system to the outlet of the total catchment via the channel routing module.

Sub-areas are established by constructing lines of equal travel time from the sub-catchment boundary to its outlet. These are referred to as isochrones.

The model storage delay parameters have been calibrated based on 10 isochronal areas making up a sub-catchment. In many instances the simple division of a sub-catchment into ten equal sub-areas provides very similar results. This is particularly true in urban areas where isochrones vary with storm frequency and can sometimes be difficult to determine due to the complexity of the pipe and overflow network.

The ten equal sub-areas are calculated automatically by xprafts. However if a user wishes to define ten isochronal areas, these must be inputted as data.

Within the workbench environment the facility for including a single sub-area, rather than the ten in xprafts, has been added.

The procedure for computing the isochrones is based on the assumption that travel for any element of area is proportional to:

$$t_t \propto \sum_{i=1}^{n} \frac{L}{\sqrt{S}}$$

Where:

t_t= travel time

L= length along a reach of the major flow path

S= average slope of the reach

The summation is carried out for each selected point in the sub-catchment along the flow path to the outlet. Laurenson’s (1964) procedure for estimating isochrones is summarized as follows:

a) A large number of points uniformly distributed over a sub-catchment are marked on a contour map of the sub-catchment.
b) For each point, the distances between adjacent contours along the flow path to the outlet are tabulated.
c) These individual distances are raised to the 1.5 power since time of flow through any reach is assumed proportional to:

$$t_t \propto \sum_{i=1}^{n} \frac{L}{\sqrt{S}}$$

ie: $t_t \propto \frac{L\sqrt{L}}{\sqrt{H}}$

Where:

H = contour interval

Since H is constant, the time of flow is proportional to $L^{1.5}$ (A correction has to be made for the lowest reach since the outlet of the catchment is not, in general, on a contour. This correction involves multiplying the length of the lowest reach by $(H/H_1)^{0.5}$ where H_1 is the fall through the lowest reach). The lengths to the power of 1.5 are then summed for each point.

d) The sums obtained in (c) are each divided by the gratest sum to give relative travel times for all points.
e) Isochrones are then drawn through the points of relative travel time to give the lines of equal travel times to the outlet. These are designated as the 1, 2, 3….10 isochrones. The areas between adjacent isochrones are referred to as the subareas.

It is recommended, unless very large sub-catchments are being considered, or flow paths and times through sub-catchments are particularly variable, that 10 equal subareas be considered to save data preparation. RAFTS provides a default for this treatment if required.

Graphical & Tabular Output

Output from the program may be specified in one of several ways:

- full output plus summary. This consists of a very comprehensive print of data and results obtained from the various modules of the program for the particular link, as well as a one page tabulated summary of data and flow results for each link of the drainage network,
- partial output plus summary. This option prints a portion of the full output as well as the tabulated summary,
- summary output only,
- summary output plus hydrograph plot. The graphical representation of the hydrograph for the particular link is included,
- partial output plus hydrograph plot plus summary.

The particular output option is specified for each link, thus one link may have full output while another appears in the summary only.

All links are listed in the summary, irrespective of the output option selected.

Hydrograph Generation Module

This module estimates sub-catchment runoff hydrographs. Of the many estimating procedures available, including unit hydrographs, empirical formulae and other runoff routing algorithms, Laurenson's non-linear runoff routing method was adopted for xprafts for the following reasons:

- It offers the most flexible model to simulate both rural and urban catchments
- It allows for non-linear response from catchments over a large range of event magnitudes
- It considers time-area and sub-catchment shape
- It offers an efficient mathematical procedure

A considerable work has been done to verify this model on Australian catchments and to date the results have been satisfactory over a varying range of catchments and rainfall events.

Data for Laurenson's model consists of catchment area, slope, degree of urbanization, loss rates and observed or design rainfall information, all of which are explained in detail below.

A limited treatment only shall be given on the theory of Laurenson's model, as a comprehensive review is given in by Aitken (1975).

Catchment Rainfall

Rainfall inputs can be either historic events or design storms. Observed spatial and temporal variations in historic events can be catered for by entering different rainfall data for each sub-catchment, according to daily rainfall and pluviograph records.

Design storms are typically inputted as a dimensionless temporal pattern combined with average rainfall intensity for the particular duration storm.

Typical design storm temporal patterns can be taken from Australian Rainfall and Runoff (Institution of Engineers, Australia, 1987) or similar references. Design storms can be varied for each sub-catchment.

Design Rainfall Bursts

In its simplest form RAFTS can be used with design storm bursts as per ARR with appropriate loss rates to estimate runoff with a similar frequency of occurrence to the rainfall itself.

This procedure is by far the most commonly applied with runoff routing techniques in a design mode to estimate frequency based design hydrographs.

Runoff frequency is, however, a function of a number of input parameters including rainfall, soil antecedent moisture and infiltration characteristics, amongst others.

Historical Events

To simulate historical events it is necessary to firstly separate excess rainfall from the total rainfall recorded and then route this excess to produce the simulated runoff hydrograph.

Data is inputted directly or via the HYDSYS dialogs and can also be read directly from a HYDSYS output file. The format of this file structure is further described in Appendix B.

xprafts allows for the input of recorded runoff hydrographs, at any node within a catchment. This may be graphically outputted together with the simulated runoff hydrograph to help calibrate appropriate loss rates and routing parameters.

Continuous Rainfall Data

Continuous runs using lengthy rainfall data sets lasting from days to years can be accommodated using the water balance module to produce excess rainfall.

The Australian Representative Basins Model (ARBM), as described by Goyen (1981), has been adopted as the appropriate water balance model.

xprafts presently performs continuous modelling automatically when the simulation period expressed as the storm duration exceeds the number of routing increments input under the storm type dialog.

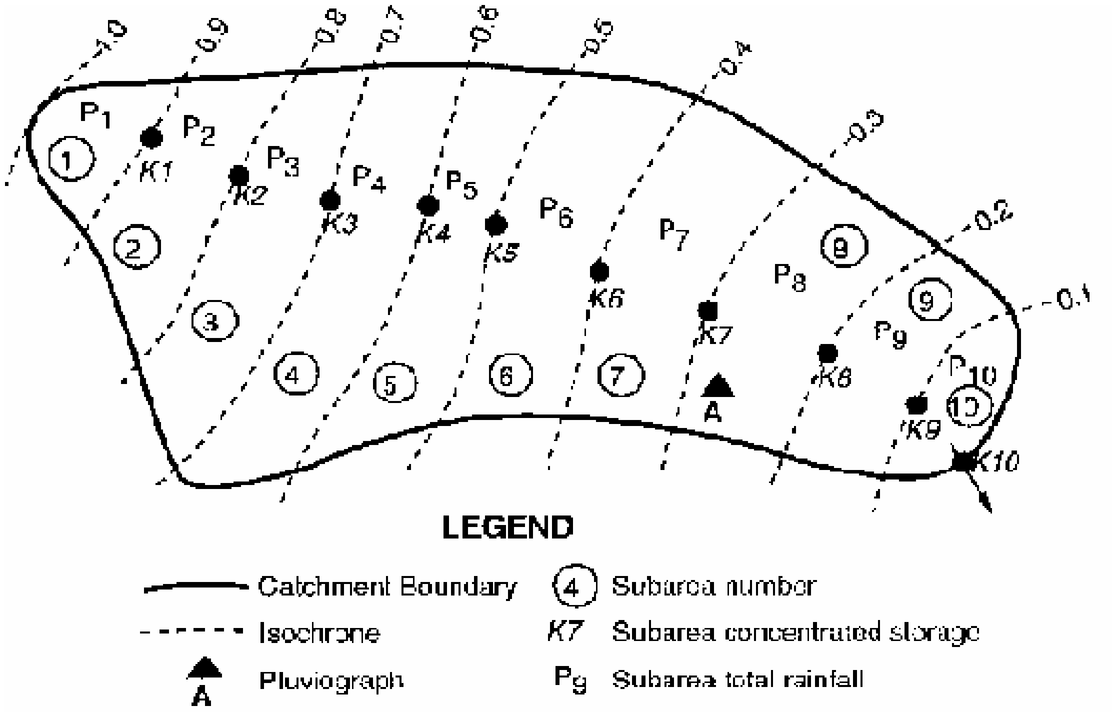
Sub-catchment Rainfall Routing Processes

xprafts makes use of Laurenson's 1964 runoff routing procedure which was primarily aimed at rural catchments but modified by Aitken (1975) for use on urban catchments.

Laurenson's method was directed at single catchments, or more particularly, the derivation of a single hydrograph at the outlet of a catchment.

In the case of xprafts, however, the sub-catchments are further divided into 10 subareas by constructing isochrones, lines of equal travel time from the sub-catchment boundary to the sub-catchment outlet.

The model storage delay parameters have been calibrated based on 10 isochronal areas, as indicated in Figure below, making up a sub-catchment. In many instances the division of a sub-catchment into 10 equal subareas provides very similar results.

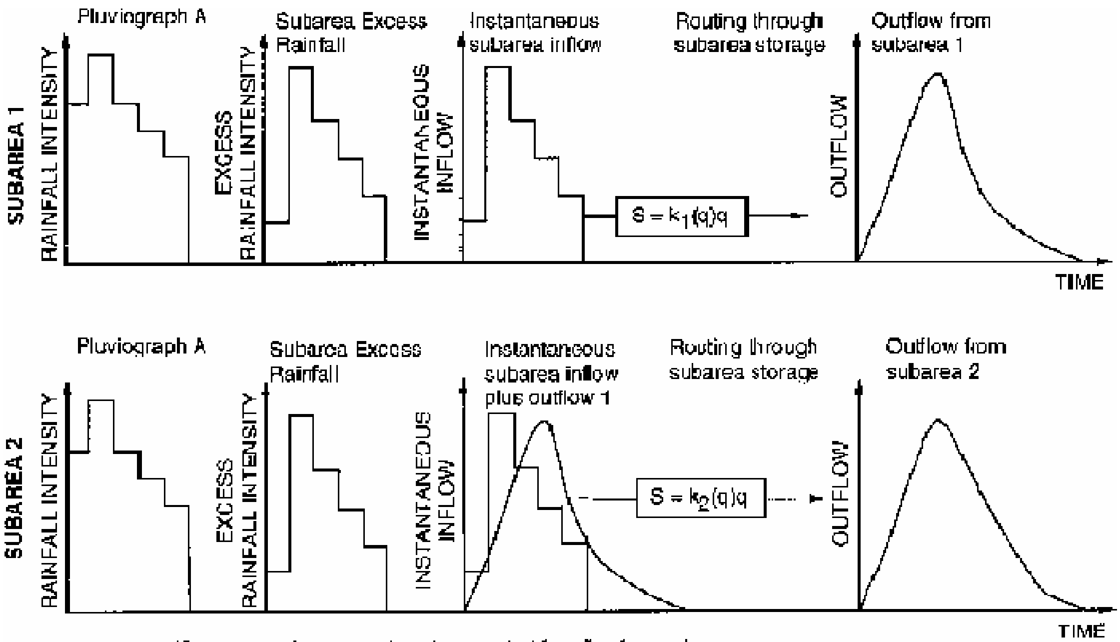


This is particularly true in urban areas where isochrones vary with storm frequency and are often impossible to determine due to the complexity of the pipe and overflow network. As previously mentioned the current workbench version also allows for a single sub-area.

xprafts uses Laurenson's method to derive separate sub-catchment outflow hydrographs.

The hydrographs so derived are manipulated through the link network to the outlet of the total catchment via the conduit routing module.

The routing method is summarised and displayed in Figure below.



(Sequence of computations is repeated for all subareas)

Routing Method

Routing for a particular sub-catchment is carried out using the Muskingum-Cunge method. The storage is considered to be a non-linear function of the discharge, ie:

$$s = K(q) \times q \qquad (1)$$

where:

s	=	volume of storage (hr × m³/s),
q	=	instantaneous rate of runoff (m³/s),
K(q)	=	storage delay time as a function of q (hours).

The storage function is used in the continuity equation in finite difference form :

$$\left(\frac{i_1 + i_2}{2}\right)\Delta t - \left(\frac{q_1 + q_2}{2}\right)\Delta t = s_2 - s_1 \qquad (2)$$

where:

i1, i2 = Inflow at beginning and end of routing period (m³/s),

delta t = routing interval (hr),

q1, q2 = outflow from the storage at beginning and end of routing period (m³/s),

s1, s2 = storage volume at beginning and end of routing period (hr × m³/s).

Substituting s2 and s1 in Equation (2) from Equation (1) gives:

$$q_2 = C_0 i_2 + C_1 i_1 + C_2 q_1 \qquad (3)$$

where:

$$C_0 = C_1 = \frac{\Delta t}{2K_2 + \Delta t} \qquad (4)$$

$$C_2 = \frac{2K_1 - \Delta t}{2K_2 + \Delta t} \qquad (5)$$

An iterative solution to Equation (3) is required due to the interrelation between C0, C1, C2, K2 and q2 in xprafts.

K1and K2 are the computed subarea storage delay times as a function of q at the beginning and end of the iteration respectively.

Storage-Discharge Relationship

Each sub-area is treated as a concentrated conceptual storage. Each storage has a storage delay time:

$$K(q) = Bq^n \qquad (6)$$

where:

K(q)	=	subarea storage delay time (hours) as a function of q
q	=	discharge (m³/s)
B	=	storage delay time coefficient

n = storage non-linearity exponent.

Substituting Equation (6) into Equation (1) gives:

$$S = Bq^{n+1} \qquad (7)$$

The default value for the non-linearity exponent xprafts is -0.285. xprafts provides the mechanisms to alter this value, usually in respect to rare events involving significant sub-catchment overbank flood routing, by:

- directly entering an amended value of "n". A value of zero would indicate linear catchment response and equate with unit hydrograph theory, or
- entering an "n" = f (Q) rating curve for each sub-catchment.

In this manner xprafts can simulate either a linear or non-linear response.

Coefficients B and n

B is either directly input for each sub-catchment or estimated from Equation (8) which was derived by Aitken (1975). The value of B for each sub-area is assumed to equal the average value of B for the sub-catchment.

$$B_{AV} = 0.285\, A^{0.52} (1+U)^{-1.97} S_C^{-0.50} \qquad (8)$$

where:

B = mean value of coefficient B for sub-catchment

A = sub-catchment area (km2)

U = fraction of catchment that is urbanised. (Where U = 1.0, the catchment is fully urbanised and when U = 0.0, the catchment is completely rural)

Sc = main drainage slope of sub-catchment (%). (The longest path of the sub-catchment, starting at sub-catchment outlet running up the main channel then if necessary branching off at the furthest tributary, to the top of the sub-catchment.)

This equation was initially derived from six urban catchments in Australia with the following ranges applying:

A varied from 0.8 km² to 56 km²

U varied from 0.0 to 1.00

Sc varied from 0.22% to 2.90%.

However over the last fourteen years a wide range of areas, slopes and urbanisation outside these ranges have been tested with a high degree of success. See Sobinoff et al. (1983).

For gauged catchments, deduced B values, evaluated as the average value from recorded rainfall/runoff events, should be used in preference to generalised regression estimates.

As U in certain instances can be rather vague, data input in this respect has been amended to include a % impervious parameter for each sub-catchment in place of the U term.

The model interprets U in terms of %I based on the following ratios:

I%	U
0	0
30	0.7
50	1.0
100	2.0*

* For regression purpose only this value is extrapolated from the original data limited of 50% impervious area.

B Modification Factors

Where gauged rainfall/runoff data is available for a range of events it should be used in preference to the above regression equation with modifying factors.

PERN

The original regression equation (Equation (8)) does not differentiate between catchments with the same degree of urbanisation but different roughnesses. An additional empirical parameter has therefore been added to take pervious sub-catchment roughness into account.

The parameter PERN is inputted as a Mannings 'n' representation of the average sub-catchment roughness. B is then modified in accordance with the following table. If PERN is left blank then B is unchanged.

Manning"n"	Multiplication Factor
0.010	0.4
0.015	0.5
0.025	1.0
0.100	3.0

Note: In urban catchments it is recommended that individual sub-catchments be split into separate impervious and pervious components. This is achieved by utilising both the first and second area dialogs. The first can relate to either the impervious or pervious, however you need to be consistent to arrive at proper component totals in the output. If OSD is being applied it is necessary to associate the first area dialog with the impervious component of the sub-catchment.

It is common for a split sub-catchment analysis to estimate a lower sub-catchment peak than a peak using only a lumped (impervious plus pervious component) sub-catchment definition.

Based on a study calibrating urban catchments in Canberra the surface runoff routing parameters for PERN Manning's roughness for impervious and pervious areas were 0.015 and 0.040 respectively. (Willing and Partners, 1993)

BX

During calibration of a gauged catchment an additional parameter BX in the header data is included to modify the calculated or input B by a further multiplication factor. The parameter BX will then uniformly modify all sub-catchment B values previously computed, or set (Equation (8)).

Note: The BX value by default is set to 1.0. This value (the Storage Coefficient Multiplication Factor in the Job Control dialog) can be varied to provide a lumped calibration for the outflow peak at the catchment outlet.

Rainfall Loss Module

xprafts currently accepts either initial and continuing losses, or infiltration parameters to suit Philip's infiltration equation using comprehensive ARBM algorithms to simulate excess runoff.

It is difficult to recommend average loss values, as soils and vegetation vary considerably. Initial losses can vary between 0 and 150 mm and continuing losses from 0 to 25 mm/h.

Loss rates should be assessed separately for each sub-catchment. Significant improvements in loss rate estimates can be obtained by catchment inspection and soil moisture and infiltration measurements over even a limited period.

Initial and Continuing Loss Model

This technique is by far the most commonly used rainfall loss abstraction procedure for models of this nature. It demands an initial loss estimate that purports to simulate initial catchment wetting when no runoff is produced, followed by a constant continuing loss rate expressed in mm/h to account for infiltration once the catchment is saturated.

This procedure is at the very best crude and can in many instances cause greater errors in runoff estimates than all the other modeling considerations combined. Although it is a commonly adopted procedure, considerable caution should be exercised with its application.

The below table gives a guide to the variations in recommended loss rates generally stated in the literature, however, this data should be used with caution.

Type of Catchment Surface	Initial Loss (mm)	Continuous Loss (mm/hr)
Impervious Areas		
Roofs of houses, factories and commercial buildings, road surfaces, etc	1.5	0
Pervious Areas		
1) Sandy, open saturated soils	5.0 - 20*	10 - 25*
2) Loam soils	5.0 - 20*	3.0 - 10*
3) Clays, dense structured soils	5.0 - 20*	0.5 - 3.0*
4) Clay subject to high shrinkage and in a cracked state state at the start of rain	25 - 35*	4.0 - 6.0*
5) ARR (1977)	0 - 50	-

* Values taken from an unpublished report by Aitken (1974) based on various textbook values

The problem of loss estimation is complicated by the fact that the design storm approach in urban drainage design infers the use of rainfall bursts rather than complete storm events. Consequently design storm loss rates need to reflect the possibilities of pre-burst catchment wetting.

Depending on historical sequences of storms and the statistical interpretation of catchment parameters, the design storm loss rates could vary greatly from those associated with complete storm analyses.

Retarding Basin Module

Attenuation of stormwater flow peaks can be achieved by temporary storage of flood waves, thus reducing the risk of downstream flooding. This can be achieved by either dynamic channel storage, or temporary reservoir storage.

This section discusses reservoir type storage generally associated with retarding basins.

Reservoir storage can be achieved using retarding basins or retention basins. Retarding basins temporarily store part of the storm flow, whereas retention basins permanently store the flow until release by pumping or infiltration at a later time.

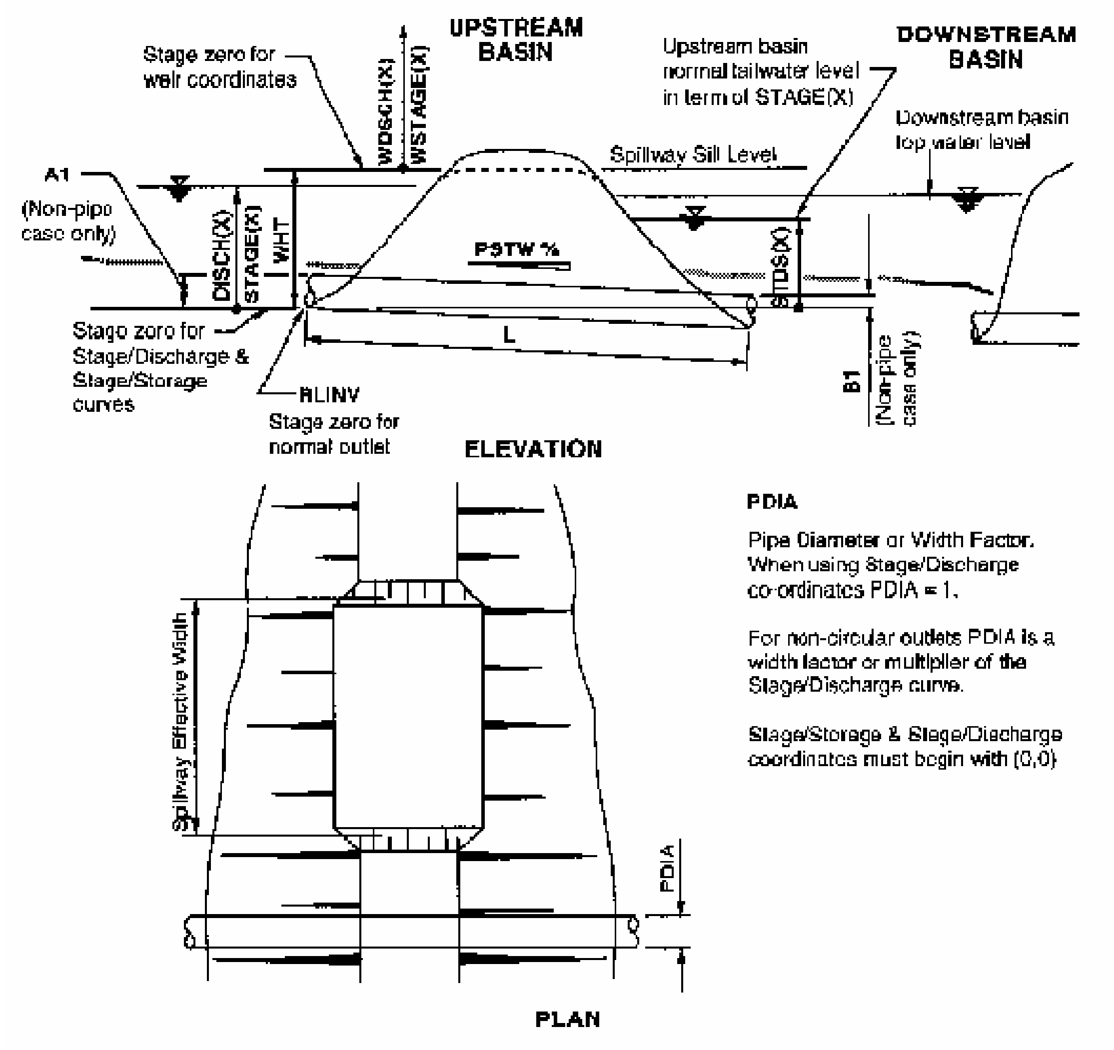
The main components of a retarding basin are an embankment, a normal outlet (generally a pipe or box culvert), and an emergency spillway. It is usual to design an uncontrolled normal outlet for a certain return period flood and allow floods greater than this to discharge over an emergency spillway.

Emergency spillways can take many forms including weir crests, glory holes and multi-level orifices and erodible embankments to name but a few.

Retention ponds are generally man-made or natural depressions. Flood gates or pumping arrangements may be necessary for eventual water release.

xprafts allows for two basic retarding basin arrangements. These are discrete basins and hydraulically connected basins. Both retarding basins and retention basins have been used extensively throughout Australia as well as overseas to provide economical and practical solutions to a range of drainage problems.

Details of specific parameters used to describe the basin characteristics as well as details pertinent to the basin's general operation are shown diagrammatically in the figure below.



Routing Details

Puls' level pool routing procedure is used in the retarding basin module. The inflow hydrograph is routed through the basin using the storage routing described below:

$$i_1 + i_2 + \frac{2s_1}{\Delta t - O_1} = \frac{2s_2}{\Delta t + O_2} \qquad (27)$$

where:

i1, i2 =	inflows at times 1 & 2 (m³/s)
s1, s2 =	total storage at times 1 & 2 (m³)
O1, O2 =	outflows at times 1 & 2 (m³/s)
delta t =	routing interval(s)

Subscripts 1 and 2 refer to the beginning and end of the routing interval respectively.

Basin Stage/Storage Relationships

A stage/storage curve must be derived for the site for use in flood routing computations.

Where investigations are undertaken using xprafts, stage/storage co-ordinates would have to be nominated for say up to 10 or 15 points along the curve, based on accurate ground survey, with intermediate points being calculated in the program by linear interpolation.

Basin Stage/Discharge Relationships

Stage/discharge data must be compiled for the normal outlets and emergency spillways. Stage/discharge data may be entered directly in coordinate form, or an option is available to use standard hydraulic equations for preliminary runs only.

Default equations presently used are:

Normal pipe outlet with h < 1.0 x diameter

$$Q_p = \frac{A_p \times R^{2/3} \times S^{1/2}}{n} \qquad (28)$$

where:

h =	height of water in basin over invert of outlet pipe
d =	pipe diameter (m)
Qp =	discharge through pipe at stage h (m³/s)
Ap =	area of flow in pipe at stage h (m²)
R =	hydraulic radius at stage h (m)
S =	pipe slope
n =	Manning's roughness (empirically set internally to 0.021) to take into account additional entrance and exit losses

Normal pipe outlet with h > 1.0d

$$Q_p = \pi \times N \times \frac{d^2}{4} \times \frac{\sqrt{H}}{\left(\frac{k_0 + k_i}{2g} + n^2 \times \frac{L}{R^{4/3}}\right)} \qquad (29)$$

where:

Qp =	discharge through pipe at stage h (m³/s)
d =	pipe diameter (m)
n =	Manning's roughness (presently set to 0.011)
L =	length of pipe (m)
H =	total hydraulic head (m)
g =	acceleration due to gravity
ki =	entry loss coefficient
ko=	exit loss coefficient
N =	number of conduits

Equation (29) assumes that the pipe flows under head when the headwater ratio (h/d) exceeds 1.0. The conduit is then assumed to operate under outlet control.

Spillway

The spillway is treated as a normal weir with an equation of the form:

$$Q_s = cwh_s^{2/3} \quad (30)$$

where:

Qs = discharge over spillway (m³/s)

c = coefficient of discharge, default set at 1.7 for a broad crested weir

w = spillway width (m)

hs = height of water above spillway.

Under basin options the weir coefficient can be set to any specified value or a weir stage/discharge curve may be used to replace the standard Equation (30).

At present the program also has the ability to handle spillways, orifice type normal outlets, fuseplug spillways, unrouted low-flow pipes through the basins. It can optimise the size of normal outlets for given basin storage volumes or maximum desirable outflow. These aspects are further discussed below.

Equations (28), (29) and (30) are generally only used for preliminary investigations. For detailed design of retarding basins it is essential to carry out separate offline detailed hydraulic investigations to derive accurate outflow characteristics as this data is the mainstay in defining the basin's operation and safety factor.

In this regard a stage/discharge curve is derived taking into account tailwater effects, flow transitions in the normal outlet flow regime, the operation of the spillways plus realistic maintenance and blockage considerations. An adopted stage/discharge curve is then inputted as a series of coordinate points.

It is possible to put in separate series of coordinates for the normal outlet and spillway provisions.

Types of Basins

Hydraulically Discrete Retention & Retarding Basins

Discrete retention and retarding basins are considered those which operate independently. In this case the stage/outflow relationship is treated as a unique function.

Hydraulically Interconnected Basins

Hydraulically interconnected basins can be analysed using xprafts. They are defined as basins that are potentially operationally dependent on the time/stage relationships of any downstream basin or basins.

xprafts uses an iterative approach to solve this type of situation and can analyse as many interconnected basins as there are links in a catchment.

Interconnected basins or basins outletting into a river have the option through variable "IFLAP" to have free two-way draining outlets or a flap gate control outlet that prevents flows back into the basin from downstream.

Reduced and possible reverse flow is presently limited to the normal piped outlet or the stage/discharge rating curve. Submergence effects, or reverse flow over spillways are presently not included. Additionally, submergence or reverse flow in the normal pipe routine is restricted to inflow heads above pipe obvert only. To date this facility has not been utilised in the workbench modelling.

Basin Outlets

Normal Outlets With Optimization

Weir Type Spillways

Fuseplug-Erodible Spillways

Low Flow Pipes Under Basins

Multiple Orifice Type Outlets With or Without Optimization

Link/Conduit Module

Flood channels encountered in small urbanised and semi-urbanised catchments offer a number of problems not normally associated with river type flood routing computations.

The conduits are usually of short length and have very marked differences in roughness, shape and slope. Lateral inflow can also form a considerable input to the channel section. As some of the channels are extremely short, sometimes down to 100 m or less, acceptable algorithms not requiring infinitely small routing increments are required.

A review of routing procedures (Price, 1973) suggested the use of a method developed by Cunge based on the Muskingum method now commonly known as the Muskingum-Cunge procedure. The method overcomes most of the analytical problems associated with other methods in so much as it accepts lateral inflow and converges with realistic time increments of the same order as the major routing increment used for the xprafts run. The routing solution provides similar response to the diffusion portion of the Saint-Venant momentum equation (De Saint-Venant, 1871). The partitioning of the momentum equation into its diffusion and kinematic components is described by Havlik (1996).

The Muskingum-Cunge procedure also allows for various factors such as channel roughness, shape and slope to be included in the deduction of suitable Muskingum routing parameters thus incorporating physical attributes that were previously not included in the Muskingum method.

The procedure described by Price was specifically oriented towards routing in British rivers and hence had to undergo minor amendment to meet the requirements of xprafts to also include minor channels and streams.

As an alternative to channel routing where physical data is lacking, xprafts allows a simple channel lagging procedure whereby the flood hydrograph is simply lagged by an appropriate time with zero attenuation. Lag times can be evaluated using Manning's equation to estimate a flow velocity.

For preliminary studies, particularly urban catchments with either steep or lined channels and pipes, it is usually sufficient to only run the lag routine. It only becomes necessary to run the Muskingum-Cunge module if the system has a significantly large channel storage component or has many branches with lateral inflow.

Muskingum-Cunge Channel Routing Model

Urban Drainage and Minor Flow Pipe Routing

Phillip's Infiltration Module

Overview

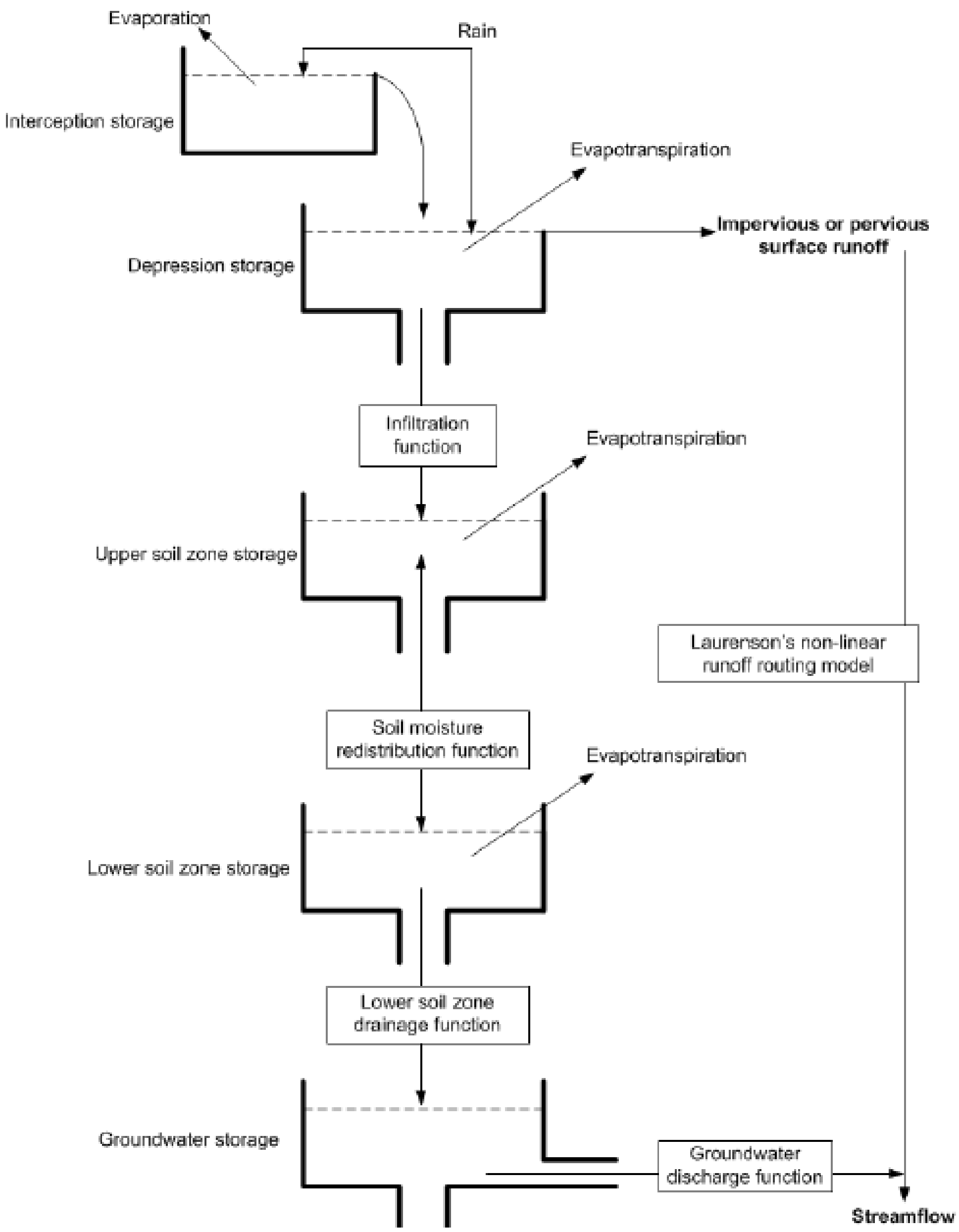
The separate loss module (LOSS) included in RAFTS employs a major segment of the Australian Representative Basins Model (ARBM) originally developed by Chapman (1968) to describe catchment infiltration and subsequent rainfall excess for a particular rainfall sequence plus catchment antecedent condition.

To utilize this module additional data describing such things as sorptivity, hydraulic conductivity, upper and lower soil storage capacities, soil moisture redistribution, groundwater runoff, and catchment drying are required.

The sensitivity of various parameters to the derived watershed runoff varies widely. Thus, a sensitivity analysis should almost always be performed to assess the critical parameters involved in the catchment calibration.

In using this loss module in an event mode, it is still necessary to provide soil moisture starting conditions prior to a design event. To achieve this some knowledge of appropriate antecedent conditions before the typical design event is required. If this information is not readily available then several values should be chosen and a sensitivity analysis carried out.

A diagrammatic representation of the LOSS Module is shown in the figure below.



The following information gives details on the major algorithms affecting the development of excess runoff during storm events:

Infiltration Parameters

Soil Moisture Redistribution

Groundwater Runoff

Catchment Drying

ARBM Process Summary

Infiltration Parameters

Sorptivity

The main theoretical infiltration algorithms are based on the work carried out by Philip (1957), when he showed that cumulative absorption or desorption into or out of a horizontal column of soil of uniform properties and initial moisture content was proportional to the square root of time.

Philip also showed that for shorter times of t, vertical one-dimensional infiltration could be described by a rapidly converging power series in t0.5. The coefficient of the leading term of the series (bracketed below) was termed sorptivity.

$$i = St^{0.5} + At + Bt^{1.5} \qquad (9)$$

where:

i =	cumulative infiltration (cm)
t =	time (minutes)
S =	sorptivity (cm/minute^0.5)
A & B	parameters of the second and third terms (cm/minute, cm/minute^1.5).

Philip (1957) and again Talsma (1969) pointed out that sorptivity depended on initial moisture content and on the depth of water over the soil. Talsma varied these parameters in a series of field based experiments to test their effect on sorptivity values.

Measurements of sorptivity were made by Talsma on large samples enclosed with 300 mm diameter, 150 mm high infiltrometer rings pushed 100 mm into the soil.

Water was rapidly ponded in the rings to a depth of about 30 mm and the subsequent drop in water level was noted at regular time increments of 10 to 15 seconds after ponding.

Talsma (1969) proposed methods of measuring sorptivity in the field on undisturbed soil, for subsequent use in analytical applications.

Sorptivities were calculated from the linear portions of initial inflow against the square root of time. Samples of soil for initial and final moisture content were taken close to and inside the rings.

Based on the work by Talsma (1969) the method relied on the reasonable assumptions that:

- during the short time of measurement (1-2 minutes) water flow would remain vertical within the ring infiltrometer, and
- that the first term of the infiltration equation (Philip, 1957) accounted for nearly all of the flow.

Allowing for the accuracy of experimental technique, the first condition, that water flow would remain vertical within the ring infiltrometer, was easily verified, but the second condition was dependent on the magnitude of A relative to S.

Talsma found that plots of I against t0.5 remained essentially linear for at least 1 minute and found that for the wide range of differently textured and structured soils studied, the drop in head during the measuring process was not significant.

Talsma concluded that the accuracy of the ring infiltrometer method of measuring S in situ was quite acceptable, even in soils with high saturated hydraulic conductivity relative to sorptivity.

Talsma also concluded that neither the diameter nor shape of the ring affected the results.

In the work carried out on the Giralang catchment by Goyen (1981), perspex rings were used, where possible, in preference to steel ones. This permitted a visual check on the wall/soil interface as well as allowing direct head drop measurements through the wall.

Sorptivities were measured at random sites over the Giralang catchment to add data to the work performed by Talsma in the Canberra region.

Hydraulic Conductivity

Hydraulic conductivity, a measurement of the ability of a section of soil profile to conduct water, is reflected in the second term in the infiltration equation by Philip (1957)

$$i = St^{0.5} + At$$

Talsma (1969) showed that for a wide range of soils, A could be expressed as follows:

$$A = \frac{K_0}{2.8} \qquad (10)$$

where:

Ko = saturated hydraulic conductivity.

Ko therefore represents the ability of a soil profile to transmit water when the soil is fully saturated. Ko is therefore only a special case of general hydraulic conductivity.

To apply Philip's infiltration equation it is therefore necessary to obtain measurements of Ko as well as sorptivity for each of the land domains.

Subsequent to reviewing the above Equations (9) and (10), a modified equation, eliminating the need for Equation (10), was cited in a paper by Chong and Green (1979).

In this publication work was described by Talsma and Parlange (1972) and Parlange (1971, 1975, and 1977) where the following equations were developed:

$$X = Y - 1 + e^{-Y} \qquad (11)$$

where X and Y were related to time, t, and accumulative infiltration, i, by the series expansion of Equation (9) and the substitution of Equation (12) and (13) in the result, with rearrangement and truncation after the t1.5 term. The relationships were:

$$X = 2K_0^2 \frac{t}{S^2} \qquad (12)$$

and:

$$Y = 2K_0^2 \frac{i}{S^2} \qquad (13)$$

The new equation termed, the "Talsma-Parlange Equation", was therefore as follows:

$$i = St^{0.5} + \frac{K_0 t}{3} + \frac{K_0^2 t^{1.5}}{9S} \qquad (14)$$

where:

i = cumulative infiltration,

S = sorptivity at a specified antecedent soil moisture content

Ko = hydraulic conductivity at water saturation.

Equation (14) was subsequently adopted in place of Equations (9) and (10) and is currently used in the xprafts loss module.

The method of measurement adopted for Ko follows a similar procedure to measuring sorptivity, only on this occasion the undisturbed core sample held by the infiltrometer ring is removed from the surrounding soil and placed on a wire grid raised above ground level. A 100 mm length of core is adopted for all Ko and S measurements.

In this way zero moisture potential at the base of the core is assured. Water is then ponded on top of the soil until a steady outflow is observed. This flow is then measured at constant head and the saturated hydraulic conductivity calculated as follows:

$$K_0 = Q_W \frac{L}{H A_c t} \qquad (15)$$

where:

Ko = Saturated hydraulic conductivity (cm/minute)

Qw = volume of water discharged in time t (cm^3)

t = time (minutes)

L = length of soil core (cm)

H = hydraulic head,
distance from base of core to pondage surface (cm)

Ac = cross-sectional area of core (cm^2)

Storage Capacity

The same samples used for the determination of saturated hydraulic conductivity can be used to measure water storage capacity in the depth of the sample.

To achieve this the sample is first weighed, then oven dried and re-weighed to deduce moisture content.

In both the hydraulic conductivity and storage capacity sampling procedure two rings can be used, one to obtain the sample and an additional ring containing an imported sample to reinstate the sampling area.

Upper Soil Storage Capacity (USC), as defined below, is an important parameter in the infiltration process using the Australian Representative Basins Model (ARBM) to relate sorptivities of varying initial moisture contents. The following relationship is used in the model as given by Black and Aitken (1977):

$$S = S_o \left(1 - \frac{US(init)}{USC}\right) \qquad (16)$$

where:

S = sorptivity

S0 = sorptivity at zero moisture content

US(init) = initial moisture content in upper soil store (mm)

USC = max. moisture content of upper soil store (mm)

Soil Moisture Redistribution

The soil moisture redistribution function forms part of the catchment drying process. It determines the quantity of water (mm) transferred between soil zones within a time interval. The expression used is:

$$RD = \frac{US - A1LS - A2}{1 - \frac{e^{RQ}}{1 + A1}} \qquad (17)$$

where:

RD = Soil moisture redistribution between lower and upper soil zone

US = current volume in upper soil zone store (mm)

LS = current volume in lower soil zone store (mm)

A1 = soil moisture redistribution constant

A2 = soil moisture redistribution constant

RQ = redistribution factor

RQ is evaluated within the program by the equation:

$$RQ = TI \times A0(1 + A1)e^{A3 \times LS} \quad RQ < 20.0 \qquad (18)$$

$$RQ = 20.0 \quad RQ \times 20.0 \qquad (19)$$

where:

TI = time interval (min)

A0 = soil moisture redistribution constant

A1 = soil moisture redistribution constant

A3 = soil moisture redistribution constant

The four soil moisture constants must be supplied as data. A value for A0 may be obtained from continuity considerations when LS = 0, as follows:

$$A_0 = \frac{1440\,A}{USC} \qquad (20)$$

where:

A = hydraulic conductivity parameter typically equal to Ko/2.8

A1 may be evaluated as the ratio of the capacities of the upper and lower soil zones, that is:

$$A1 = \frac{USC}{LSC} \qquad (21)$$

where:

LSC = maximum moisture content of lower soil zone (mm).

A2 and A3 are usually set to zero.

If the result obtained by evaluating Equation (17) is negative then the flow is from the lower soil zone to the upper soil zone. If the result is positive then the flow direction is from the upper soil zone to the lower zone.

Lower Soil Zone Drainage

The groundwater store is replenished by water draining from the lower soil zone store. The percentage of the contents of the lower soil zone store that drain to groundwater is a function of how close to full the lower zone store is.

The quantity of water draining from the lower zone, however, is independent of the status of the groundwater store and is obtained as follows:

$$LDR = LS\left(1 - e^{TF \times LDF \sqrt{LS/LSC}}\right) \qquad (22)$$

where:

LDR = lower soil zone drainage

TF = time interval (days)

LDF = lower soil drainage factor

Groundwater Runoff

The groundwater store is the only source of runoff in dry weather. That is, it provides the baseflow component of the streamflow. The quantity of groundwater runoff in a time interval is determined by the recession equation:

$$GR = \frac{GS}{GN}\left[\sqrt{TF}\left(1 + 2GN \times KG \times GS^{GN-1}\right) - \sqrt{TF}\right] \qquad (23)$$

where:

GR = groundwater runoff

KG = constant rate groundwater recession factor

GN = variable rate groundwater recession factor

TF = time interval (days)

GS = current value of groundwater storage (mm)

Equation (23) expresses the groundwater runoff as a depth over the pervious part of the catchment. It must be converted to a depth over the entire catchment. The conversion is made as follows:

$$GR = FPER \times GR \qquad (24)$$

where:

FPER = pervious fraction

ARBM Process Summary

When applied to urban catchments the pervious and impervious areas are considered separately. Only the pervious areas are considered when natural catchments are being modelled (unless it is known that part of the natural catchment behaves like an impervious surface).

Three processes are modelled for the pervious areas; catchment wetting, catchment drying and soil moisture redistribution. Five levels of storage are used. These are interception, depression, upper and lower soil zone and groundwater stores.

In the catchment wetting phase rain falling on the pervious areas goes simultaneously to the interception and depression storages. Once the interception store is full it also overflows into the depression storage. The infiltration process begins as soon as there is any moisture in the depression storage and continues until the depression store is empty. The infiltrating water enters the upper soil zone.

Catchment drying is by evapotranspiration which occurs from the interception, depression and upper and lower soil zone stores. The full potential evapotranspiration based on pan readings is applied first to the interception store. If it is depleted before the evapotranspiration requirements are met then the residual evapotranspiration capacity is applied to the depression store. If the depression store is unable to meet the requirements then the remainder is applied to the upper and lower soil zones.

Soil moisture is redistributed between the upper and lower soil zones concurrently with the catchment wetting and drying phases. Moisture may flow either to or from the upper soil zone. A certain proportion of the moisture in the lower soil zone drains to groundwater storage, which gives rise to groundwater runoff.

One storage is used for the impervious areas. It is filled by rainfall and depleted by evaporation.

Runoff is generated in three ways, by overflow of the impervious area store, overflow of the depression storage due to infiltration limitations and groundwater runoff.

The first two sources of runoff, which are the surface runoff components, are combined preparatory to routing. The groundwater runoff is routed separately and is added to the routed surface runoff to give the total estimated runoff volume for each day.

Impervious and Pervious Areas Loss Parameters

Impervious Areas Loss Parameters

The impervious area of a catchment consists of those impervious surfaces which are directly connected to the catchment drainage system. Typical impervious surfaces are roadways, parking areas, paths, roofs, and occasionally rock outcrops.

The volume of runoff from the impervious parts of the catchment is governed by one parameter. That is the Capacity of the Impervious Area Storage (CAPIMP). CAPIMP represents the maximum volume of water that may be trapped in small depressions in the impervious areas. Typical values are:

Gentle to steep slopes – 0.6 to 1.2 mm

Flat slopes – 1.2 to 1.5 mm

The value chosen will generally affect the runoff volume generated by small storms only.

The impervious areas are likely to be the only source of surface runoff for small storms and the predominant source of surface runoff for many larger storms as well. Consequently these two parameters are of crucial importance when calibrating the model for urban catchment.

Pervious Areas Loss Parameters

Seventeen parameters govern the volume of runoff from pervious areas. The parameters considered include:

IAR

ISC

DSC

USC

LSC

UH

LH

ER

S0

Ko

A0

A1

A2

A3

GN

LDF

KG

The most important are S0, Ko, ISC, DSC, USC, and LSC

LDF and KG are important in the determination of groundwater runoff, but since this is usually a comparatively small part of the total runoff volume the overall importance of these two parameters is not generally very great.

The table below is taken from a Thesis by Goyen (1981) and lists typical values of ARBM parameters used in Canberra for residential lawns, playing fields, dry grass and Eucalyptus Forests.

Typical ARBM Parameters for Canberra Catchments

Parameter	Ref Set	Dry Grass	Resid* Lawns	Irrig.** Playing Field	Natural Forest
CAPIMP	0.5	0.5	0.5	0.5	0.5
ISC	1.0	1.0	1.0	1.0	1.0
DSC	5.0	1.0	1.0	1.0	1.0
USC	12.5	12.5	12.5	12.5	12.5
LSC	200.0	12.5	25.0	25.0	100.0
UH	10.0	10.0	10.0	10.0	10.0
LH	10.0	10.0	10.0	10.0	10.0
ER	0.7	0.7	0.7	0.7	0.7
GN	1.0	1.0	1.0	1.0	1.0
KG	0.94	0.94	0.94	0.94	0.94
S0	7.0	4.5	10.0	10.0	10.0
Ko	1.4	0.42	0.84	1.18	0.42
LDF	0.05	0.05	0.05	0.05	0.05
IAR	0.7	0.7	0.7	0.7	0.7

* .05 mm/hr domestic lawn watering was applied over the summer months.

** .23 mm/hr domestic irrigation water was applied over the summer months plus .115 mm/hr over the winter period.

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