

REALM USER MANUAL

(Edition for REALM Version 6.28)

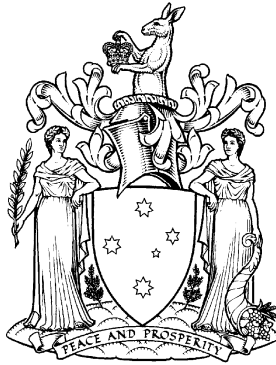
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**Department of
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**VICTORIA
UNIVERSITY**

**A NEW
SCHOOL OF
THOUGHT**

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Conventions used in this text

::	This symbol is used to denote that the phrase to the left side is the parent menu and to the right side is the sub-menu item.
<i>Project::New Directory</i>	Phrases in Italics along with the menu symbol are the menu items.
“Project”	Text extracted from the title of a dialog box, title of a tab, or general text to be highlighted.
Bold	Phrases in Bold format are used to highlight important points.
	Grey highlighting over white text indicates a button with that title in a dialog box.
<i>' Hint '</i>	Descriptions of a button shown when the mouse pointer moved onto it, Radio button labels or any other text in the program window.

Chapter 1

1 INTRODUCTION

1.1 WHAT IS REALM?

REALM (REsource ALlocation Model) is a water supply system simulation package. It is general in that any water supply system can be configured as a network of nodes and carriers representing reservoirs, demand centres, waterways, pipes, etc. It is flexible in that it can be used as a 'what if' tool to address various options (i.e. new operating rules, physical system modifications, etc.). System changes can be quickly and easily configured and investigated. A wide range of operating rules can be modelled either directly or indirectly by exploiting the basic set of node and carrier types and their corresponding attributes.

It uses a fast network linear programming algorithm to optimise the water allocation within the network for each time step of the simulation period, in accordance with user-defined operating rules.

The user can specify the desired level of detail of output from the model. Output can be presented graphically, either in raw form or after post-processing using a suite of utility programs separate from the simulation model. Input and output data files have the same format and can easily be transferred to commercially available word processing and spreadsheet packages such as Microsoft Office to enhance presentation and/or to perform more detailed statistical analyses.

The theory of REALM is given in Perera and James (2003).

1.2 CREDENTIALS OF REALM

The REALM package has been developed in close conjunction with its major users and many enhancements have been made in response to suggestions and feedback from the users. As a result, not only it is now able to meet the needs of a diverse set of users in the water industry, but also it has developed into a comprehensive tool for water supply planning and management.

REALM has been adopted as the modelling standard for water resource planning and management in Victoria and is the key analytical tool for reviewing and quantifying water entitlements for water authorities as part of the Victorian Reform Process. There are now REALM water resource planning models of all major water supply schemes in Victoria, South Australia and Western Australia. It is also gaining popularity in Tasmania, Australian Capital Territory and Northern Territory. REALM can also be used as a teaching tool and for research purposes.

REALM has proved its credibility in the water industry as a user-friendly, reliable and powerful tool to address water supply planning and operational issues. Two case studies are given in Perera, James and Kularathna (2005).

1.3 STRUCTURE OF REALM

The REALM package is a suite of programs that creates input data files, sets up a simulation run, performs a simulation and processes output files. The structure of REALM is shown in Figure 1-1.

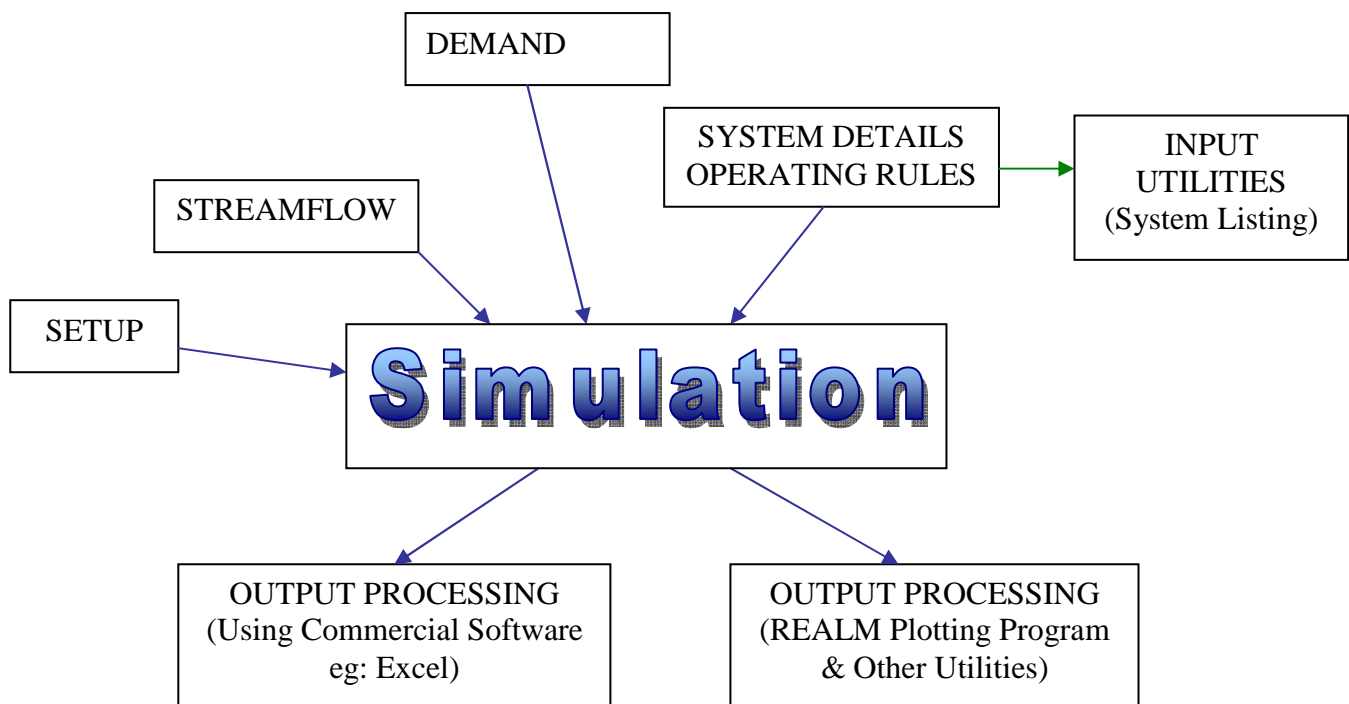


Figure 1-1 Basic Structure of REALM

1.3.1 INPUT FILES

REALM requires three types of input files. They are streamflow files, demand files and system files. The first two files can be created using a standard text editor such as Notepad in Windows. The system file is created using the System Editor (SE). It is possible to have a number of streamflow, demand and system files for a simulation run.

1.3.2 SIMULATION

Once the streamflow, demand and system files are prepared, the simulation involves running two separate programs, Setup (S) and Run (R). Program S sets up all run time parameters required for the simulation and saves these parameters in a file called *ans_file.dat*. Program R reads this file and other input files (Section 1.3.1 above), and performs the simulation.

1.3.3 PROCESSING OUTPUT

REALM is capable of producing a number of output files. They fall into different categories as given below:

- reservoir (seven output options)
- demand (six output options)
- stream junctions (one output option)
- carriers (four output options)
- water quality (two output options)

The output files have the same format as streamflow and demand files. They are text (or ASCII) files containing columns of data with several lines of header information.

Seven utility programs are available to perform basic processing of these REALM output files. They are:

- Plot
- Filter
- Rank
- Format Conversion
- Calculator
- Merger
- Replicate Analysis.

The users may write their own routines and use other application software, such as Microsoft Excel, to process the output data of these REALM output files.

It is also possible to save all output data of nodes and carriers in a database in binary form. The required information on output can then be extracted through a utility called *Data Base Extraction*. This is a useful option for large water supply networks consisting of hundreds of nodes and carriers, which eliminates the need to re-run the simulation model with different run setups.

In addition, there are two programs, *LP Solver* and *LP Extract*, which can be used for debugging of infeasible solutions of a REALM network. It also includes a *Streamflow Transformation* utility which is used to alter inputs.

1.4 TYPICAL APPLICATIONS OF REALM

REALM allows modelling of single and multiple reservoir systems that are constructed for single and/or multiple purposes such as urban water supply, irrigation, hydropower etc. REALM can model almost all features of water supply systems, including:

- Complex water transfers between various elements (i.e. reservoirs, demand zones, transfer mains, diversion structures etc.) of the system
- Urban and irrigation restriction policies
- Complex rules for allocating water to irrigation (e.g. carryover)
- Irrigation demand modelling with PRIDE
- Sharing of water resources between various bulk users (i.e. capacity sharing)
- Environmental flows
- Water quality
- Climate change scenarios.

In addition, external routines can be linked with REALM to model complex planning and operational issues of water supply systems.

As mentioned earlier, there are REALM planning models for major water supply systems in Victoria, South Australia and Western Australia. Some Victorian REALM models are as listed below.

- River Murray system: This is the largest REALM model, which incorporates features such as capacity sharing and continuous accounting to keep track of water usage of two major users (i.e. Victoria and New South Wales). An external routine is linked with REALM to model the irrigation allocation issues and restriction policy. The reach storage is modelled because of long travel time in the system. The operational loss is also modelled. Like all other REALM models, the environmental flows are also modelled.
- Goulburn, Campaspe and Broken River system: This REALM model is a composite model of Goulburn, Campaspe, Loddon and Broken river systems, serving a large irrigation area and some rural towns. Both urban and irrigation restriction policies are considered. The environmental flows are also modelled.
- Melbourne system: The REALM model of Melbourne's water supply system is a large model. It models the water demands of Melbourne's three retail water companies and the supplies to regional water authorities. The model mainly includes urban demands, but also represents private diversion demands and farm dam impacts in water supply catchments. The environmental flows are modelled, and the modelling undertaken by Melbourne Water for future planning of the system is based on 'recycled historical streamflow sequences'.
- Werribee system: This system model considers both urban and irrigation demand restriction policies. The capacity sharing of water resources between three users are considered in the model with water usage accounting. The environmental flows are also modelled.

1.5 INSTALLATION OF REALM

This section provides details on installing REALM on Windows 95/98 or 2000/NT/XP operating systems.

1.5.1 DOWNLOADING & INSTALLING REALM SOFTWARE AND MANUALS

Downloading procedure is same for both Windows 95/98 and 2000/NT/XP systems. Follow the steps given below to download REALM software and manuals.

1. Access the Water home page of the Victorian Department of Environment and Primary Industries through <http://www.water.vic.gov.au/>.
2. Click on "Monitoring & Reporting"
3. Click on "Surface Water Modelling"
4. Click on "REALM". This opens a window that enables the user to download REALM software and/or REALM manuals, and to find out about training available for the use of REALM.
5. Click on "Download REALM Software"
6. Follow the instructions. It is necessary to download the installation file into a temporary subdirectory. Go to the temporary subdirectory and double-click on the downloaded file to extract (or unzip) the installation files (including the setup file). This will extract the installation files into a directory specified by the user (the default is *C:\Program Files\REALM\Install subdirectory*).

7. Finally, run the setup program in the Install subdirectory and follow the instructions to install REALM on to your computer. This will install REALM in Programs List. All programs with required data files and user manuals are stored in *C:\Program Files\Realm subdirectory*. The data files required to run the Getting Started tutorial and Worked Examples tutorials are stored in *C:\Program Files\Realm\GetStart* and *C:\Program Files\Realm\WorkedExamples* subdirectories respectively. The user manuals (including the Getting Started Manual, REALM Manual and Worked Examples Manual) are stored in *C:\Program Files\Realm\Manuals* subdirectory. These manuals can be read via an Acrobat Reader.

1.5.2 REALM SETUP ON NETWORKS

As long as the directions specified above are followed for the different operating systems then no special steps are required to install the files on a network.

1.5.3 DOWNLOADING REALM MANUALS

In order to download the REALM software manuals only, first follow steps (1) to (4) of Section 1.5.1. Then, click on "Download REALM Manuals". This opens a window listing all of the available REALM manuals. Click on the name of the relevant manual. Follow the instructions to view the contents of the manuals through Acrobat Reader and then to save.

1.6 LAYOUT OF MANUAL

Chapter 2: describes the preparation of streamflow input data files.

Chapter 3: describes the preparation of demand input data files.

Chapter 4: provides an overview of the REALM Program Manager, which allows the access to various REALM operations. This chapter introduces Project directory and its use in REALM.

Chapter 5: describes the System Editor in detail.

Chapter 6: presents details of setting up a simulation with Program Setup (S) in REALM.

Chapter 7: presents details of running a REALM simulation once input data files (i.e. streamflow, demand, system and setup files) are prepared. This section also describes the output files of a REALM simulation.

Chapter 8: discusses REALM output utilities.

Chapter 2

2 STREAMFLOW FILES

2.1 GENERAL

The streamflow file consists of seasonal (i.e. monthly, weekly or daily) streamflow and climatic parameters. They can be either historic or generated data. The streamflow data represent the unregulated inflows into the system, which are available for harvest at reservoirs and/or stream junctions. The streamflow data at the nodes should represent the flow from the intermediate catchments. That is, the streamflow data at a harvesting node should be the streamflow generated from the catchments between this node and the adjacent upstream harvesting node(s).

The climatic variables, such as temperature and rainfall, are used to model the reservoir evaporation losses. Variables known as “climatic indices” are used to compute seasonally adjusted monthly demands from annual demands. The use of climatic variables and “climatic indices” in REALM is discussed in Section 5.4.4.3 and Section 5.5.1 respectively under reservoir and demand node editing.

2.2 STRUCTURE OF STREAMFLOW FILES

The streamflow file has a specific format as listed below:

- identifying label (should be ####2)
- four lines of documentation, titles etc. describing streamflow data
- FORTRAN format of data
- number of data items (should be within the first 4 columns of this line)
- data item labels (up to 20 characters per label)
- data.

The first line should always be ####2, which is the streamflow file identifier. The next four lines should be used to include the information describing the streamflow file and data. The sixth line shows the FORTRAN format of data. The FORTRAN format of data for the streamflow file used in this example is explained later. The next line should show the number of data items in the file and **should be entered within the first 4 columns of the line**.

The headings of the data items should appear next, each heading on a separate line and limiting the length of the heading to 20 characters. The number of headings should match the number of data items. The headings should represent the data items and therefore, the headings should be in the same order as the corresponding data items (which are in the form of columns of data).

The first two lines of headings contain two important key words, SEASON and YEAR, which indicate the time reference. SEASON denotes the month, the week or the day, while YEAR denotes the year. The presence of both keywords indicates the seasonal (i.e. monthly, weekly or daily) data, whereas the presence of YEAR alone indicates the annual data. The keyword REPLICATE is optional and is used if a number of streamflow replicates is used. REPLICATE, when used, is in the third line of data item labels. All keywords should be spelled correctly with upper case letters.

The other headings are the names of data columns of streamflow into the system (through reservoirs and stream junctions), the names of climatic data columns (e.g. evaporation and rainfall) used in computing the reservoir evaporation losses, and the

names of so-called “climatic index variables” or “climatic indices” columns used in generating monthly demands from annual demands to allow for the climatic conditions. **During the simulation, REALM matches these names with the information given in the system file. Therefore, it is necessary to enter these names in the streamflow file exactly same (including the case) as in the system file.** If these names could not be matched, the simulation terminates during run time with an error message of ‘missing data’.

Figure 2-1 shows a part of a streamflow file. There are eight data items, each data item occupying 12 digits including 2 decimals and decimal point. They are real numbers and referred as *Floating Point Values* (and hence the F format). **It should be noted that the data are always right justified within the allocated columns.** That is, in Figure 2.1, all data items end at the columns defined by multiples of 12. The FORTRAN format statement for this case is (8F12.2). Alternatively, this can be written as (F12.2,F12.2,F12.2,F12.2,F12.2,F12.2, F12.2,F12.2) or even (4F12.2, 4F12.2).

```

####2
FILE MANIP UTILITY OUTPUT FILE
18 columns transferred from 1 input file

Time 12:11:03 Date 1-JUN-90
(8F12.2)
8
SEASON
YEAR
EILDON STOR INFLOW
COLIBAN STOR INFLOW
EPPALOCK BELOW COLI
CAMPASPE WEIR BELOW
LODDON ABOVE LAANE
CASEY'S FLOW
  1.00    1893.00    31366.00    1304.00    35.00    0.00    2872.00    2838.00
  2.00    1893.00    15859.00    493.00    0.00    0.00    1709.00    1581.00
  3.00    1893.00    11982.00    546.00    0.00    0.00    1780.00    1626.00
  4.00    1893.00    15330.00    881.00    0.00    0.00    9692.00    2855.00
  5.00    1893.00    43700.00    9163.00    11278.00    3595.00    77304.00    11658.00
  6.00    1893.00    264141.00    23542.00    83947.00    15260.00    220159.00    74496.00
  7.00    1893.00    371101.00    16053.00    54767.00    6555.00    96581.00    101242.00
  8.00    1893.00    260088.00    8106.00    42767.00    8987.00    52899.00    61869.00
  9.00    1893.00    419559.00    10308.00    55489.00    9410.00    86044.00    118968.00

```

Figure 2-1 Part of a Streamflow File (F-Format)

On the other hand, Figure 2-2 has data items defined as integer values (I). However, each data item occupies different number of digits in a row. Figure 2-3 shows the number of digits occupied by different data items in the file shown in Figure 2-2. The FORTRAN format statement in this case is (I2,I6,I13,I7,3I5). Alternatively, this can be written as (I2,I6,I13,I7,I5,I5,I5).

```

####2
REALM
GETTING STARTED - TUTORIAL EXAMPLE
STREAMFLOW DATA
JULY -1997
(I2,I6,I13,I7,3I5)
7
SEASON
YEAR
INFLOW1
INFLOW2
CLINX
RAIN
EVAP
1 1996      1250      312      110      30      70
2 1996      1150      219      110      50      60
3 1996       800      202      105      60      50
4 1996      1400      175      100      70      40
5 1996      2480      712      100      75      35
6 1996      9600     1018      90      90      25
7 1996      8910     1608      90      95      10
8 1996     11200     3701      100      90      25
9 1996     10650     1870      105      80      35
10 1996      7400     2350      105      70      40
11 1996      4230     1728      110      50      50
12 1996     10578      926      115      40      60
1 1997      1400      667      110      30      70
2 1997      1550      451      110      50      60
3 1997      1230      302      105      60      50
4 1997      2100      256      100      70      40
5 1997      3460      723      100      75      35
    
```

Figure 2-2 Part of a Streamflow File (I-Format)

Data Item	Data Column Name	Number of Digits
1	SEASON	2
2	YEAR	6
3	INFLOW1	13
4	INFLOW2	7
5	CLINX	5
6	RAIN	5
7	EVAP	5

Figure 2-3 Number of Columns Occupied by Data Items to Define FORTRAN Format Statement

The use of REPLICATE is optional for a single replicate of streamflow and is used only when multiple replicates of streamflow data are used. In this case, an additional column of data is required to define the REPLICATE. When preparing the data, for each time reference, data representing the first replicate is given first, then those of the second replicate and so on until those of the last replicate is given. The second time reference is considered then and the above procedure is repeated. All time references are considered in a similar manner until the data for the last time reference are considered. Part of a streamflow file with 3 replicates is shown in Figure 2-4.

Several streamflow files can be considered in a single REALM simulation run. The use of multiple files allows grouping of different types of data in separate files. For example, the streamflow data can be in one file, while the climatic parameters can be in a different file. Or data relevant to major rivers of the network can be in different

files. During simulation, REALM reads the contents of all streamflow files until the end of the files. **Therefore, there should not be blank lines or control characters on the last line of each streamflow file, which will cause problems during simulation run time. Furthermore, the streamflow file should not contain negative streamflow values, although negative evaporations are allowed.**

```
#####2
Multi replicate data file
sample only
3 replicates only
( 5f12.2          )
5
SEASON
YEAR
REPLICATE
STREAM1
EVAP
1.00    1920.00    1.00    16186.00    37.00
1.00    1920.00    2.00    20166.32    38.09
1.00    1920.00    3.00    22236.21    51.36
2.00    1920.00    1.00    18329.00    46.00
2.00    1920.00    2.00    20034.20    53.23
2.00    1920.00    3.00    23575.22    29.61
3.00    1920.00    1.00    12852.00    76.00
3.00    1920.00    2.00    11777.63    70.74
3.00    1920.00    3.00    12738.95    102.19
4.00    1920.00    1.00    12424.00    145.00
4.00    1920.00    2.00    15302.29    176.17
4.00    1920.00    3.00    16335.81    197.02
5.00    1920.00    1.00     237.00    203.00
5.00    1920.00    2.00     283.54    257.42
5.00    1920.00    3.00     168.17    200.24
6.00    1920.00    1.00    1107.00    242.00
6.00    1920.00    2.00     954.28    260.91
6.00    1920.00    3.00    1164.20    234.22
```

Figure 2-4 Part of a Streamflow File with Multiple Replicate Data

2.3 USE OF STREAMFLOW FILES

The information in the streamflow files is accessed and used in REALM in two different ways, depending on the contents of the demand files (Chapter 3). They are:

1. If the demand file(s) has seasonal information (i.e. monthly, weekly, daily, etc.), then the streamflow information is accessed and used by (exactly) matching the simulation time step (both season and year) with that of SEASON and YEAR columns of streamflow and demand files. For example, the streamflow and demand data of January 1996 are used for January 1996 simulation time step. Single or multiple replicates of both streamflow and demand data can be used. In this case, streamflow file(s) should have seasonal data as in the demand files (i.e. monthly, weekly, daily, etc.)
2. If the demand file(s) has annual data, the information on the streamflow files is considered to be "sample" data. The first full streamflow year in the streamflow files is accessed first with the first annual demand defined by the start time step of the simulation (defined during the simulation Setup - Section 6.3.2). Each subsequent streamflow year is accessed in turn with the

subsequent annual demand until the end of the simulation. This approach is used for “future planning” studies, where the annual demand can be predicted based on factors (e.g. population growth, per capita water consumption) other than future climatic data, and is generally used for urban water supply planning studies. In this case, the streamflow files may or may not have the replicate column for single replicate runs, while they have the replicate column for multiple replicate runs. The demand files should not have the replicate column. In this case, data in streamflow files are in months.

When a **single replicate of streamflow** is considered in REALM simulation, the demand files can be prepared either as in case (1) or (2) above.

For case (1) where the demand file is defined by seasonal (i.e. monthly, weekly, daily, etc.) data, it is necessary to have some concurrent data in the streamflow and demand files, although the two data sets can be of different lengths (i.e. at least there should be a certain number of years of common data in these files). The simulation period can be the full period defined by these files or a sub-set of the full period. In any case, both streamflow and demand files should have concurrent data for the simulation period. During the run time, the simulation extracts the correct streamflow and demand data corresponding to the simulation time step.

For case (2) where the demand file is defined by annual data, streamflow data are considered to be “sample” data and therefore, the YEAR column in streamflow file can be anything. The YEAR column of the streamflow files do not have to match with the YEAR column of the demand files (i.e. REALM does not use the YEAR column of the streamflow files). **However, the streamflow records in the streamflow file should be for full calendar years.** Further, the demand files should have the YEAR column of data to reflect the future planning years. The simulation period can be the full period defined by the demand file or a sub-set of the full period. Furthermore, the simulation period may start from any month of the year and finish in any month of the year, as long as the starting and finishing years are defined in the demand files. The simulation accesses the correct annual demand data from the demand files corresponding to the first year of simulation and disaggregates the annual demand into monthly demands. However, the simulation accesses the first year of streamflow data from streamflow file(s). REALM then performs the simulation for the first year (or part of the first year) with extracted monthly streamflow and annual demand data. Then the next year is considered and so on, until the simulation is completed.

When **multiple replicates of streamflow** are considered in REALM simulation, the demand files can be prepared either as in case (1) or (2) above.

The use of REALM with multiple replicates of streamflow for case (1) is same as for the single replicate case. In addition, if required, a less number of replicates can be considered in the simulation than what is given in the streamflow and demand files, and in this case, only replicates that appear first in the data files will be used.

The use of REALM with multiple replicates of streamflow for case (2) can take two forms, as follows.

- Streamflow data are given as one replicate. In this case, REALM uses the “recycled historical streamflow sequences” approach of McMahon and Mein (1986) to generate the streamflow replicates. The recycled streamflow sequences are

generated by concatenating the historical streamflow sequence by itself and considering each sequence as starting with a new year of the historical record, but continuing for N number of years, where N is the number of years in historic streamflow data sequence. This method can generate a maximum of N streamflow replicates, which are different to each other. The user can perform the simulation for a less number of replicates than N , and can be set up during REALM Set up (Section 6.3.1)

- Streamflow data are given as multiple replicates. If required, a less number of replicates can be considered in the simulation than what is given in the streamflow files, and in this case, only replicates that appear first in the data files will be used.

Table 2-1 summarises the types of simulation runs that can be performed in REALM depending on the format of streamflow and demand files.

Table 2-1 Input File Combinations for REALM Simulation Runs

Streamflow	Demand	Remarks
<i>Single replicate runs – all single replicate data</i>		
Seasonal	Seasonal	Season can be monthly, weekly, daily etc.; commonly used for both urban and rural (or irrigation).
Seasonal	Annual	Seasonal in this case is monthly; usually used in urban planning considering predicted forecast demand.
<i>Multiple replicate runs</i>		
Seasonal (multi-replicate data)	Seasonal (multi-replicate data)	Season can be monthly, weekly, daily etc.; commonly used for both urban and rural (or irrigation).
Seasonal (multi-replicate data)	Annual (single replicate)	Seasonal in this case is monthly; usually used in urban planning considering predicted forecast demand.
Seasonal (single replicate)	Annual (single replicate)	Seasonal in this case is monthly; usually used in urban planning considering predicted forecast demand; multiple replicates are generated using “recycled historical streamflow sequences” approach of McMahan and Mein (1986).
Seasonal (single replicate)	Seasonal (multi-replicate data)	Not available in REALM.

Chapter 3

3 DEMAND FILES

3.1 GENERAL

The demand file consists of time series demand data for various demand zones of the water supply system. The demand data can be either historic water usage or predicted future demands. They can be either seasonal (i.e. monthly, weekly or daily) or annual. If annual demands are specified in the demand files, the monthly demands are generated within REALM from the annual demands, using the monthly demand disaggregation factors and the "climatic indices". The use of demand disaggregation factors and the use of "climatic indices" in REALM are discussed in Section 5.5.1.

Different streamflow and demand input file combinations based on the type of data (i.e. monthly/annual) and streamflow replicates can be considered in REALM and are discussed in Section 2.3.

3.2 STRUCTURE OF DEMAND FILES

The structure of the demand file is identical to that of the streamflow file. Once again the columns of demand data are preceded by the header information. However, the identifying label for the demand file should be #####3. The presence of the YEAR keyword alone indicates annual data, while both SEASON and YEAR indicate seasonal (i.e. monthly, weekly or daily) data. As in the streamflow files, the keyword REPLICATE and associated replicate column is optional. **The keywords should be spelled as above in upper case letters.**

The REPLICATE column is not applicable when annual demand data are given in the demand files, even though the multiple replicates can be considered in the simulation. In this case, the multiple replicates of streamflow are generated using the "recycled historical streamflow sequences" approach of McMahon and Mein (1986). These streamflow replicates are used in the simulation with the demands as given in the demand files, considering the same annual demand for each streamflow replicate.

The column header names (except the keywords) describe the demand nodes, which are given in the system files. **These header names should be exactly same (including the case) as the demand node names in the system files.** During simulation, REALM matches these header names with demand node names. If these names cannot be matched, the simulation terminates during run time with an error message of 'missing data'. Data columns represent the demands in the form of either seasonal (i.e. monthly, weekly or daily) or annual data, depending the SEASON/YEAR keyword(s).

Several demand files can be considered in a single REALM simulation run. The use of multiple files allows grouping of different types of data in separate files. For example, the urban demand data can be in one file, while the data corresponding to irrigation (or rural) demands can be in a different file.

During simulation, REALM reads the contents of all demand files until the end of the files. **Therefore, there should not be blank lines or control characters on the last line of each demand file, which will cause problems during simulation run time. Furthermore, the demand file should not contain negative values.**

A sample demand data file is shown in Figure 3-1. The description of the format statement is same as in streamflow files. Multiple replicate demand files have the same format as the multiple replicate streamflow files.

```
####3
DEMANDS DATAFILE
HISTORICAL DATA
DATA ASSEMBLED AND REFORMATED ON
DATE : 9 JUL 1990
( 4F12.2)
  4
SEASON
YEAR
DEMAND 1
DEMAND 2
  1.00      1982.00      2700.00      2700.00
  2.00      1982.00      1300.00      1300.00
  3.00      1982.00      2100.00      2100.00
  4.00      1982.00      1500.00      1500.00
  5.00      1982.00      1600.00      1600.00
  6.00      1982.00       700.00      1700.00
  7.00      1982.00      1200.00      1200.00
  8.00      1982.00      1800.00      1800.00
  9.00      1982.00      2200.00      1200.00
 10.00      1982.00      1300.00      1300.00
 11.00      1982.00      1400.00      2400.00
 12.00      1982.00      1400.00      1400.00
  1.00      1983.00      1900.00      1900.00
  2.00      1983.00      1100.00      3100.00
  3.00      1983.00      1300.00      1300.00
  4.00      1983.00       800.00      1800.00
  5.00      1983.00       0.00      2000.00
  6.00      1983.00       600.00      1600.00
  7.00      1983.00       900.00      1900.00
  8.00      1983.00       300.00      1300.00
  9.00      1983.00       600.00      1600.00
 10.00      1983.00      1400.00      1400.00
```

Figure 3-1 Part of a Demand File

Chapter 4

4 REALM PROGRAM MANAGER AND PROJECT DIRECTORIES

4.1 GETTING STARTED

The REALM banner will be displayed at the start of REALM and will automatically disappear after a few seconds. Click on the left mouse button anywhere outside the banner to advance to the next window. The REALM Program Manager (Figure 4-1) is displayed then. Note the two label compartments of the status bar at the bottom of the window. The left label indicates that the last project directory used in this computer was `C:\realm1`. REALM automatically re-opens the last project directory. Hence, in this example, the current directory is `C:\realm1` and the user can start using REALM in this directory.

The right label shows the system file (or the first system file of multiple system files) used in the last application of the project directory `C:\realm1`. In this case, it is shown as *'Not found'*, since there has not been a proper REALM run done in this project directory. REALM is structured into four Main Menus according to their function in REALM Program Manager (Figure 4-1), as follows.

- Project Directories
- System Configuration
- Simulation (Run)
- Utilities

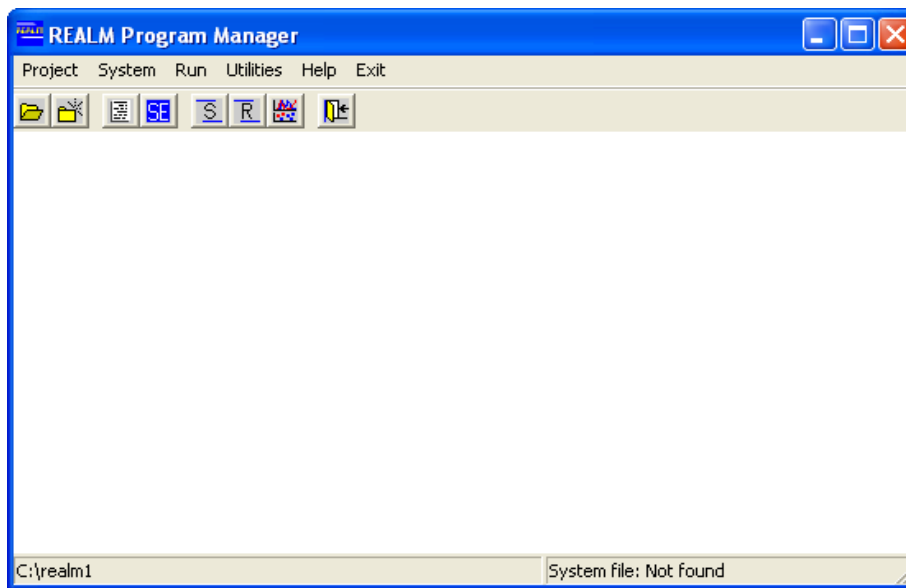


Figure 4-1 REALM Program Manager

Figure 4-2 describes the buttons in the toolbar of this REALM Program Manager window.

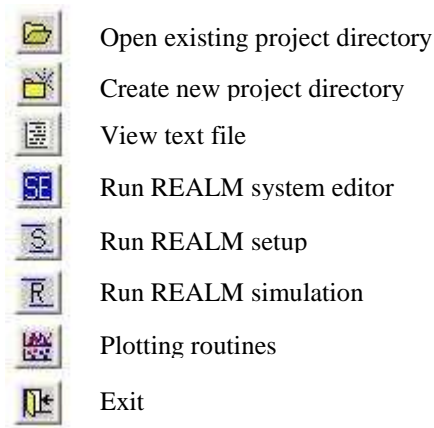


Figure 4-2 REALM Program Manager Tools

4.2 PROJECT DIRECTORIES


The *Project* menu has two menu items, as follows:

- New directory
- Open directory

In addition, there is a separate partition under *Project*, which shows up to 5 previous project directories used in this computer. Figure 4-3 shows these project directories. Double click on any of these project directories to make it the active directory and start using REALM in this directory. When this is done, the left and right labels of the status bar change to the selected project directory and the system file (or the first system file of multiple system files) respectively. If REALM has not been used in this computer before, no directory or system file will be shown on the status bar.

4.2.1 CREATING PROJECT DIRECTORIES

To create a new project directory, click on *Project::New directory*, as shown in Figure 4-4 (a) **or**

Click on the  'Create new project directory' button on the tool bar. This will display a window (Figure 4-4 (b)).

The text field of the dialog box shown in Figure 4-4(b) shows the current project directory (the previous project directory used in this computer), as shown in the status bar of REALM Program Manager (Figure 4-1).

Type in the required project directory name with appropriate full path in the text box **or**

Use the browser in the second compartment to select the parent-directory and then append the new project directory name in the text box.

Click on the **OK** button.

Clicking on **Cancel** in Figure 4-4 (b) takes the user back to the REALM Program Manager (Figure 4-1), without creating a new project directory.

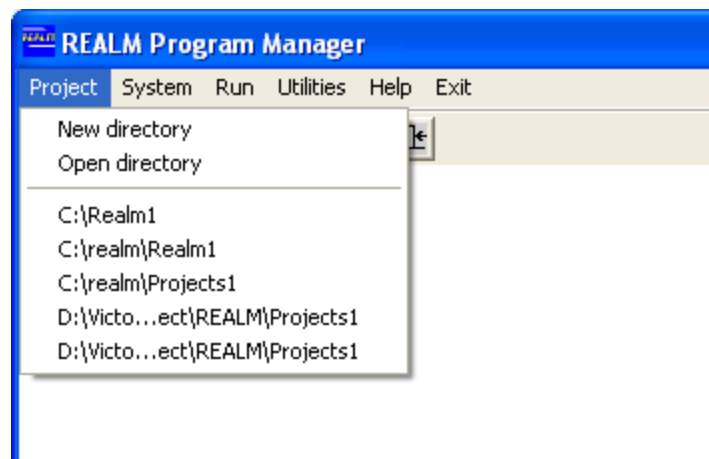


Figure 4-3 REALM Program Manager Showing Previous Project Directories

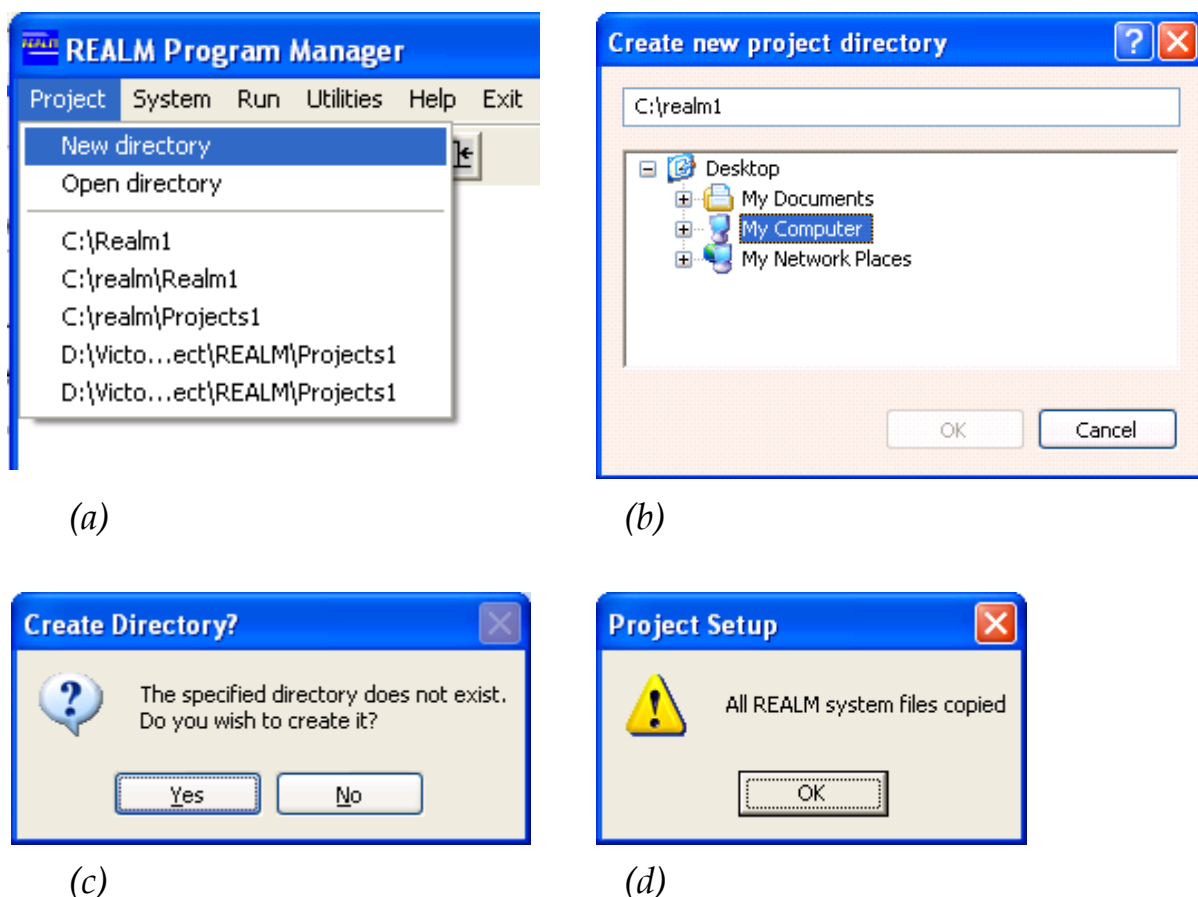


Figure 4-4 Setting up a New Project Directory (a) Menu Option for Creation (b) Assignment of Name & Location for the New Project Directory (c) Permission to Create a Folder in the File System (d) Confirmation Screen

Click on **Yes** and **OK** in the next consecutive windows as shown in Figure 4-4 (c) and Figure 4-4 (d) respectively to create the required project directory. Clicking on **No** in Figure 4-4(c) takes the user back to Figure 4-4(b).

Once the project directory is created, the REALM Program Manager window (Figure

4-1) is displayed again, with the newly created project directory shown in the left label of the status bar. The user is now ready to run a REALM application in this project directory.

It is necessary to create new project directories through the REALM Program Manager (as instructed above) for REALM applications. This will ensure the required files are automatically copied into the project directory to run REALM. **Do not use Windows Explorer to create REALM project directories.** REALM does not run in directories created by methods other than through the REALM Program Manager. Note also that the browser in REALM cannot “see” zipped files.

All output files will be stored in the project directory. It is also a good practice to store all input files in the project directory, although it is not necessary.

To perform many functions (e.g. System Listing) REALM needs to be able to write to the working directory. For this reason, **files on CD should be copied into a writable directory before working with those files in REALM.**

4.2.2 OPENING EXISTING PROJECT DIRECTORIES

Opening an existing project directory can be done in two ways.

Method 1: If the directory is one of the most recent five projects

Click on the *Project* menu item in the REALM Program Manager to display the window in Figure 4-3, listing the most recently used (up to) five REALM project directories.

Click on the required project directory. The REALM Program Manager window (Figure 4-1) will be resumed with the opened project directory, which will be shown on the left label of the status bar. The right label shows the system file (or the first of multiple system files) used under the opened project directory. The user is now ready to run a REALM application in this project directory.

Method 2: To open an existing REALM project directory

Click on *Project::Open directory*, as in

Figure 4-5(a) **or**


Click on the  'Open existing project directory' button (i.e. first button) on the tool bar. This will display a window (

Figure 4-5(b)) to open an existing project.

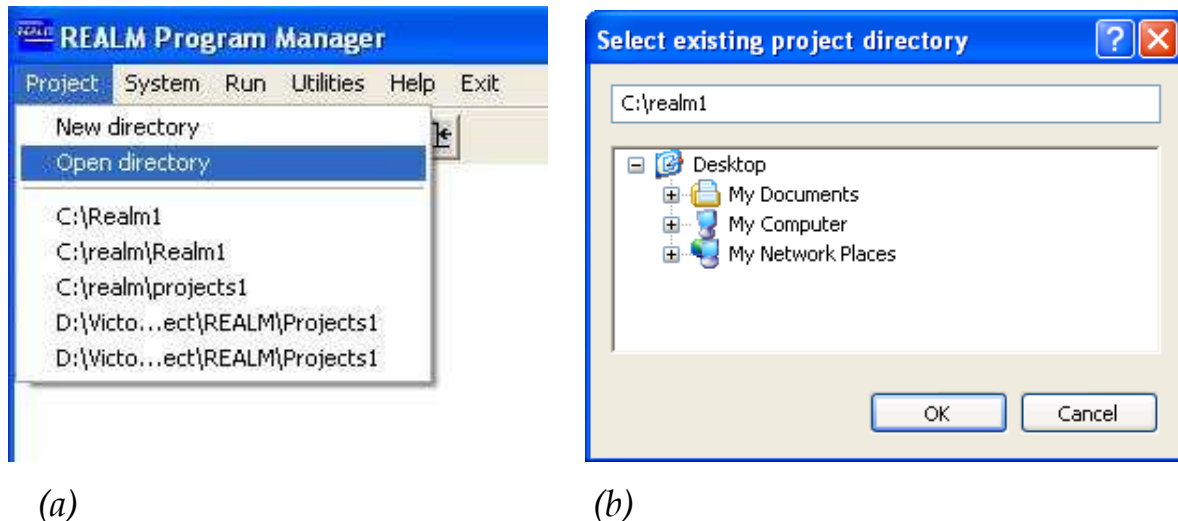


Figure 4-5 Select Existing Project Directory (a) Menu Selection (b) Open Directory Window

Similar to Figure 4-4 (b), this window (Figure 4-5 (b)) can be used in two ways to open an existing project directory. Type in the exact directory name with its path **or**

Use the directory browser at the bottom part of the window to locate the project directory.

Click on **OK** to confirm and open the specified REALM project directory, and return to the REALM Program Manager window. Clicking on **Cancel** on

Figure 4-5 (b) takes the user back to the REALM Program Manager window (Figure 4-1) without opening the selected project directory.

Once the required project directory is opened, the REALM Program Manager window (Figure 4-1) shows the opened project directory on the left label of the status bar. The right label shows the system file (or the first of multiple system files) used under the opened project directory. The user is now ready to run a REALM application in this project directory.

4.3 SYSTEM CONFIGURATION

There are three menu items listed under system:

- REALM System Editor
- Text Editor
- Listing

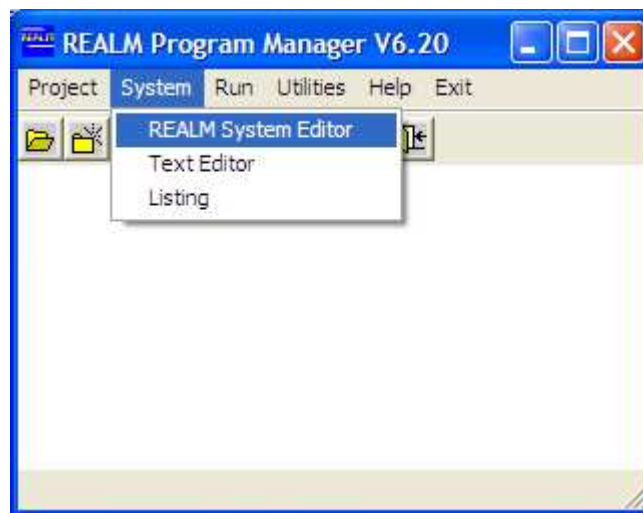



Figure 4-6 REALM System Menu List


4.3.1 REALM SYSTEM EDITOR (SE)

SE provides a graphical interface for creating a system file or making changes to an existing system file.

The System Editor can be accessed through the *System::REALM System Editor* menu item (Figure 4-6) or the  'Run REALM System Editor' button on the toolbar of the REALM Program Manager (Figure 4-1). The details of SE are given in Chapter 5.

4.3.2 TEXT EDITOR

The Text Editor is similar to Notepad in Windows. It can be used to view and edit text (or ASCII) files. Since it is similar to Notepad in Windows, the details are not given in this User Manual.

The Text Editor can be accessed through the *System::Text Editor* menu item or the  'View text file' button on the toolbar of the REALM Program Manager (Figure 4-1). This displays a standard browser window for selecting and opening files, and allows the selection of different subdirectories and also different file types as listed below.

- All files
- REALM system files
- REALM log files

Once the required file is opened, the standard editor operations can be performed as in Notepad in Windows. **Note that the Text Editor needs to be closed before proceeding with other REALM operations.**

4.3.3 SYSTEM LISTING

This program converts the system file created by the System Editor to a file called *system_temp.lis*, which has system details with header information. The *system_temp.lis* file can be easily read and the system details can be identified by the user. System Listing can be accessed through the *System::Listing* menu item of the REALM Program

Manager (Figure 4-1). The details of the System Listing function are given in Section 5.11.

4.4 SIMULATION (RUN)

The Run menu is sub-grouped under three partitions as follows and shown in Figure 4-7.

- Setup
- Model
- File viewer
- DOS executable
- DOS prompt
- Macro
- Options

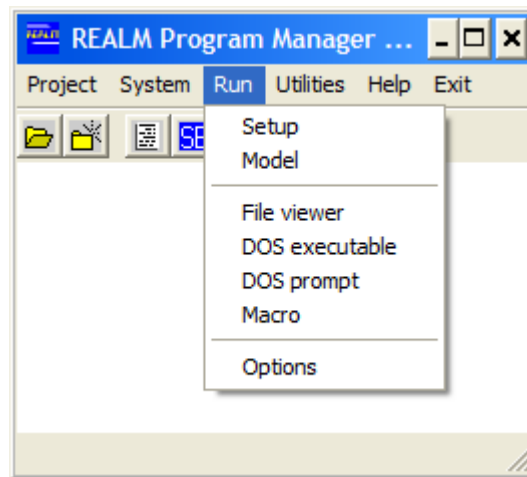




Figure 4-7 Run Menu Listing

4.4.1 SETUP

This program sets the run time parameters of the simulation. Setup can be accessed through the *Run::Setup* menu item or the  'Run REALM Setup' button on the toolbar of the REALM Program Manager (Figure 4-1). The details of REALM Setup (S) are given in Chapter 6.

4.4.2 MODEL

This program performs the simulation, and can be accessed through the *Run::Model* menu item or  'Run REALM' button on the toolbar of the REALM Program Manager (Figure 4-1). The details of REALM Run (R) are given in Chapter 7.

4.4.3 FILE VIEWER

The File Viewer is identical to the Text Editor (Section 4.3.2).

4.4.4 DOS EXECUTABLE

This option has been retained to enable the user to operate in DOS (for very old REALM files). Refer to the June 2001 edition of the User Manual for details of this option.

4.4.5 DOS PROMPT

This option has been retained to enable the user to operate in DOS. Refer to the June 2001 edition of the User Manual for details of this option.

4.4.6 MACRO

This option enables the user to automate tasks by creating a macro script file which includes instructions to execute REALM commands. It allows tasks to be undertaken such as loading a scenario file, changing aspects of the scenario file, including log filename, input filenames, start and end dates of simulations and the specified system file. It also allows system file information to be changed, such as the equation in any variable capacity carrier or the maximum capacity of any carrier within the given system file. A user manual for the macro option may be downloaded at: http://www.water.vic.gov.au/monitoring/surface-water-modelling/realms/download_realms_manuals.

4.4.7 RUN OPTIONS (OR DEFAULT REALM SETTINGS)

There are several default settings used by REALM in performing the simulation. They are related to:

- Time step used in simulation
- Output formats
- Convergence, tolerances and iterations
- Dynamic memory
- Files / output
- Water quality parameters.

These default settings are stored in a file called *realm.set*, which is stored in the project directory. This file is copied to the project directory, when creating a project directory using *Project::New Directory* (Section 4.2.1). These default settings stored in *realm.set* can be changed to suit the current REALM application by clicking on *Run::Options*. This will display the “General Options” dialog box (Figure 4-8). Note that the “Time step” tab is active in Figure 4-8.

4.4.7.1 SIMULATION TIME STEP

In most applications, a monthly time step is used as the simulation time step. However, the REALM models using daily time step are becoming popular especially in modelling environmental flows and water quality. The time step can be changed by clicking on the “Time step” tab of *Run::Options*, which displays the dialog box shown in Figure 4-8. Note that there are 4 time steps available: daily, weekly, monthly and linear. Click on the appropriate time step to suit the user’s application. Linear is any regular time step other than daily, weekly and monthly, such as hourly, 2-hourly etc.

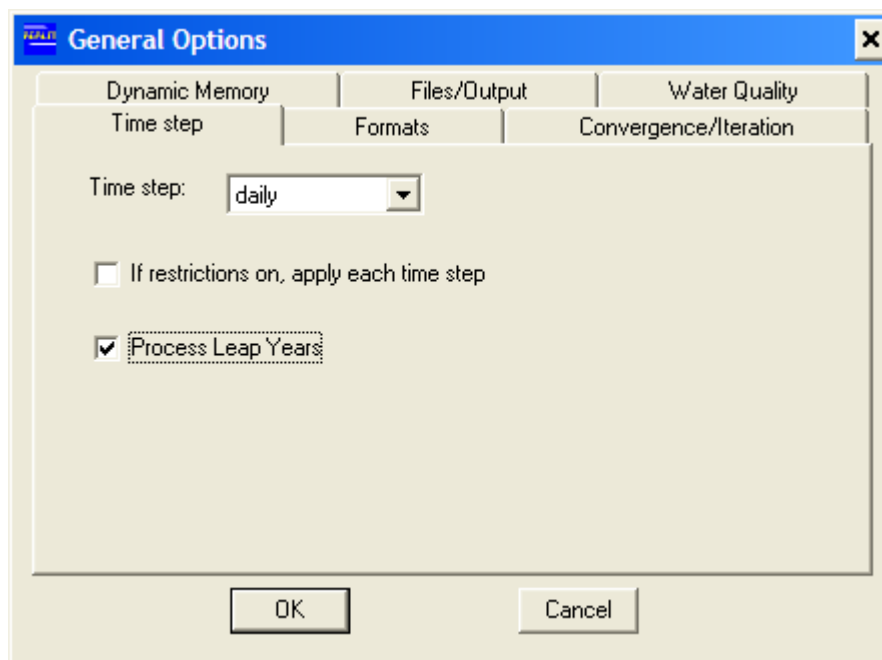


Figure 4-8 Time Step Tab in REALM Options

The modelling time step should be consistent with the data in the streamflow, demand and system files. For example, if the time step is set as monthly in *realm.set* file or in Figure 4-8, then the streamflow and demand data should be specified in months. Similarly, the capacities of carriers and other similar variables in the system file should be monthly values.

The check box *'If restrictions on, apply each time step'* is used only for daily models with irrigation (or rural) demand restrictions. If the check box is not checked, allocations will be calculated on the first day of the month and the same allocation will be used for each day of the month. If it is checked, then allocations will be re-calculated each day.

The check box *'Process Leap Years'* is used for daily models to recognise an extra day in leap years.

4.4.7.2 OUTPUT FORMAT

Click on the "Formats" tab of *Run::Options*, which displays the dialog box shown in Figure 4-9. This dialog box allows the user to change the default settings for the format of the output files. The log file and other output files, such as storage volume and flow files, can be changed using the fields of *'Utility format'* and *'Simulation format'* respectively. In Figure 4-9, f12.0 format has been used. The user is referred to Section 2.2 for details of these FORTRAN format statements.

REALM will read data files that contain decimal places, but as it can only operate with integers in allocating water within the water supply system (through the Network Linear Programming algorithm), it needs to convert decimals to integers. The "Input streamflow and demand data" block allows the user to specify how REALM will round the decimal fraction. It is recommended to use the *'Round all input data prior to LP'* option. This option allows REALM to utilise decimals that may be included in input files in calculations prior to use in the LP, such as in variable capacity carriers. At the point where integers are necessary for use in the network

linear programming solution, all values are rounded to the nearest integer.

If the 'Round all input data prior to LP' option is not selected, one of two other rounding options must be selected. The 'Round down' option is very similar to the 'Round all input data prior to LP' option, in that decimals are rounded just prior to use in the LP. However, 'Round down' converts decimals to whole numbers by taking the integer portion of the number (i.e. rounding down), whereas 'Round all input data prior to LP' rounds decimals to the near integer (rounding up or down). The 'Round to nearest integer' option rounds the streamflow and demand data (in streamflow and demand files) to the nearest integer before they are used in other calculations, such as variable capacity carriers, and then used in solving the flows in the network.

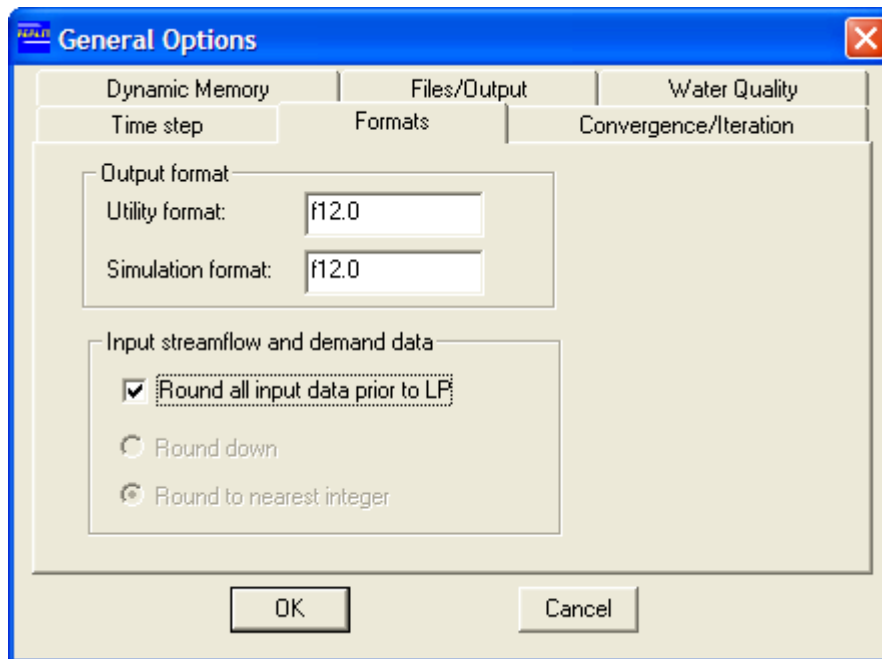


Figure 4-9 Formats Tab in REALM Options

4.4.7.3 CONVERGENCE, TOLERANCES AND ITERATIONS

REALM uses several iterations at each time step to converge to the solution (i.e. flows in the carriers and final storage volumes of the reservoirs). This is required because of the assumed values for certain variables at the start of each simulation time step and the dependence of carrier capacities on flows of other carriers. Several convergence criteria are considered in REALM and their tolerances can be changed from the default values to suit the current application.

Click on the "Convergence/Iteration" tab of *Run::Options* to change the tolerances of convergence criteria and information on iterations. The dialog box shown in Figure 4-10 is displayed. The user is advised to retain the Minimum iteration count as (at least) 3, so that there will not be any premature convergence. The default maximum iteration count is set at 51. If the solution is not converged for a particular simulation time step with the maximum iteration count, this is recorded in the simulation log file (Section 7.2.1). In this case, the user may want to change the Maximum iteration count. However, the user is then advised to use LP dump and diagnostics programs (Section 8.8) to investigate the cause for non-convergence at this time step, before changing the Maximum iteration count.

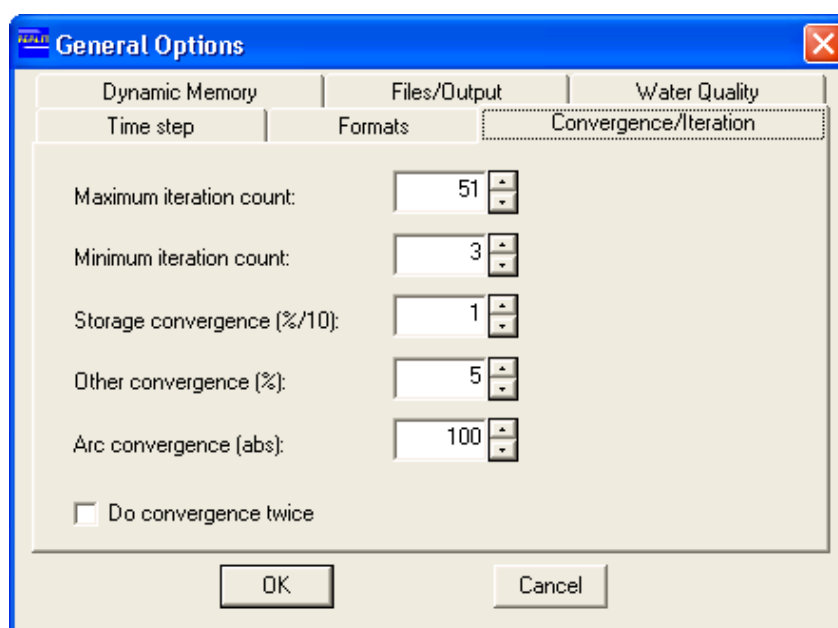


Figure 4-10 Convergence/Iteration Tab in REALM Options

The convergence for storage volume of each reservoir is governed by a fine tolerance (0.1% as the default from one iteration to the other in Figure 4-10). Experience shows that it is necessary to have a fine tolerance for storage volumes, although it can be changed. There are other aspects of convergences required, such as when the capacity of a carrier depends on the flow of another carrier or when the transmission losses of carriers are expressed as percentages of their flows. In both above examples, it is assumed that the flows in these carriers change from one iteration to another during a simulation time step. These tolerances can be set through the 'Other convergence' field. Note that this tolerance is generally a coarser tolerance compared with the Storage convergence tolerance. However, still there may be cases, especially with large systems with complex operating rules, where certain carriers do not converge with the tolerance given in the 'Other convergence' field. In this case, the 'Arc convergence (abs)' can be set in absolute values. Then during the simulation, flows in carriers are considered to be converged if the flows in the carriers satisfy one of the above two criteria namely, 'Other convergence' or 'Arc convergence'. Again, the user is advised to use LP dump and diagnostics programs (Section 8.8) to investigate the cause for non-convergence at this simulation time step, before changing these tolerances.

Sometimes complex daily models need extra iterations to ensure convergence. The 'Do convergence twice' check box allows an extra iteration during a simulation to ensure convergence. When this check box is checked, REALM compares the results of three successive iterations for convergence before it moves on to the next simulation time step. If the check box is not checked, REALM compares the results of two successive iterations.

4.4.7.4 DYNAMIC MEMORY

REALM software can be used to model any water supply system with any complex operating rules, without recompiling the source code, unless the water supply system is modelled with a very large number of nodes and carriers. This has been achieved through the use of dynamic memory capabilities on maximum number of replicates in using generated data in the application (MAXREP), maximum number of data rows in

streamflow and demand files (MAXP) and maximum number of water quality pointers (MAXSALPT). Water quality pointers are used in REALM to track a large number of variables for water quality calculations, including all carriers to and from each node. Basically the bigger the number of nodes and carriers in a REALM model with water quality calculations, the bigger MAXSALPT needs to be. However, these default settings of these parameters can be changed by clicking on the “Dynamic Memory” tab of *Run::Options*, which displays the dialog box shown in Figure 4-11.

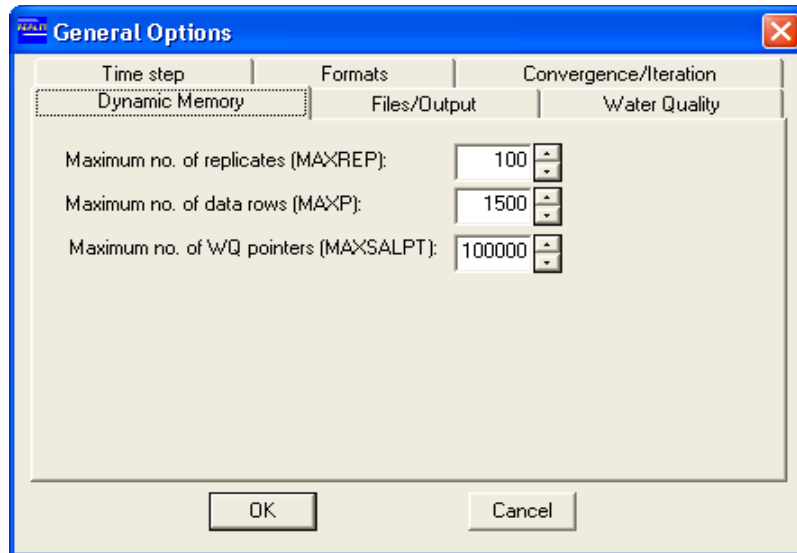


Figure 4-11 Dynamic Memory Tab in REALM Options

4.4.7.5 FILES/OUTPUT

Click on the “Files/Output” tab of *Run::Options* to change the Font Size / Font Style and to request certain other output files for the application (if required). This will display Figure 4-12. ‘Font Size’ and ‘Font Style’ contain standard options. However, the user is advised to use “System Fixed” (which is the default option) to get the values properly aligned with the headings in REALM output files.

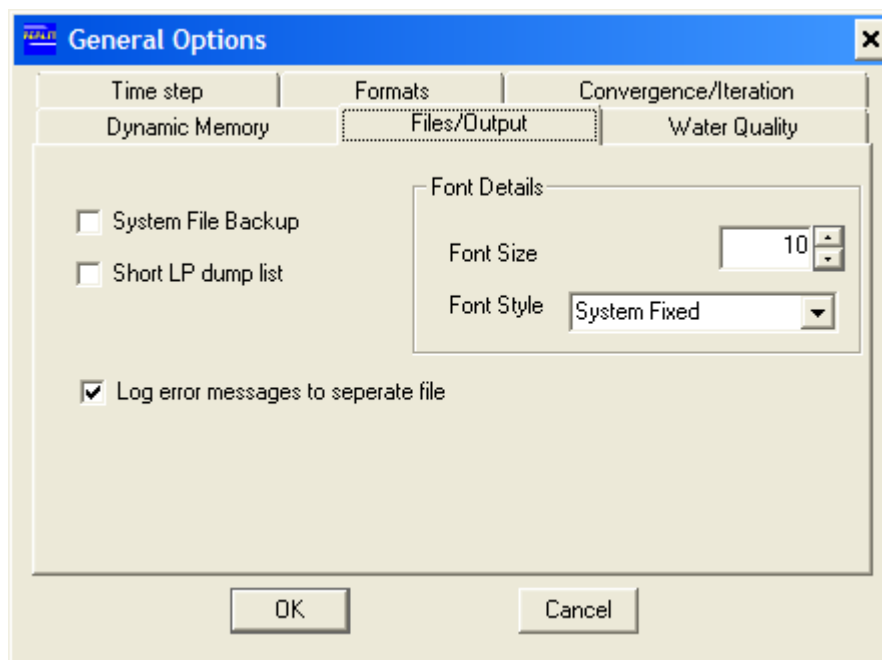


Figure 4-12 Files/Output Tab in REALM Options

The check box '*Short LP dump list*' gives a LP dump for each simulation time step only for the arcs that have non-zero flows.

Tick the check box '*System File Backup*' to automatically generate a backup of the system file when it is opened, called *sys.bak*, without the changes made since the system file was last saved. (Note to open this backup file in the REALM System Editor, first change the file extension to *.SYS* in Windows Explorer.)

Tick the check box '*Log error message to separate file*' to separate run-time error messages (Section 7.1.1) from the main log file and create a separate error log file. The error log file will be named as '*[Log file name]_error.log*'. If this is not ticked, the error messages, if any, will be included in the log file itself.

4.4.7.6 WATER QUALITY

REALM can model up to 4 water quality parameters. REALM uses simple "mixing" at nodes and transports "loads" through carriers, but does not consider any dispersion. Conservative water quality constituents, such as salinity and turbidity, can be modelled explicitly with REALM. Non-conservative constituents (e.g. biodegradable materials, temperature, etc.) can be innovatively modelled using variable capacity carriers. The user is referred to the following paper for theory of REALM water quality modelling and an application:

Theory of Water Quality Modelling Using REALM, is described in Perera, B. J. C. and Seker, M. P. (2000).

The water quality parameter names can be changed by clicking on the "Water Quality" tab of *Run::Options*, which displays the dialog box in Figure 4-13. These parameter names can be considered as arbitrary and the names do not dictate the water quality processes.

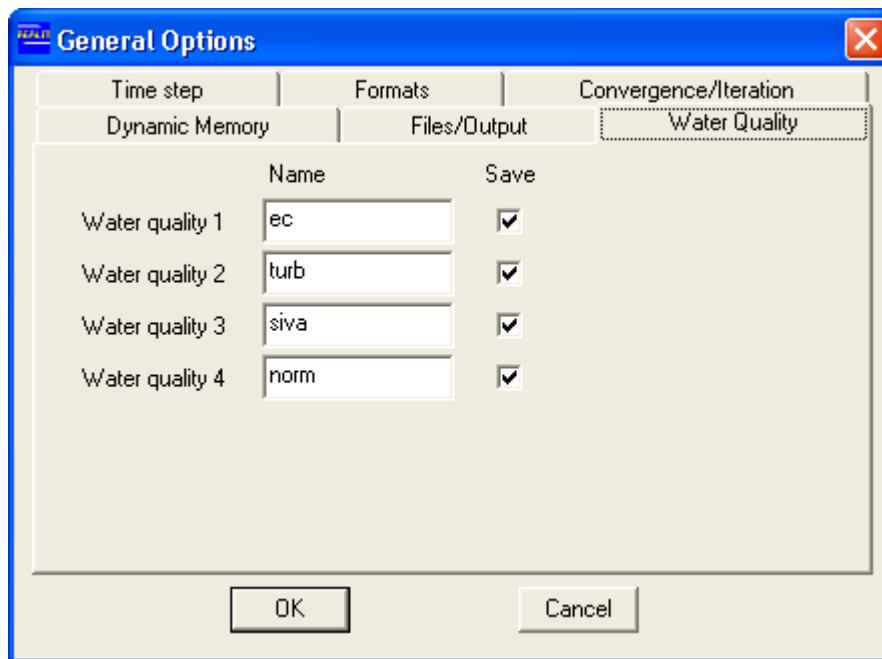


Figure 4-13 Water Quality Tab in REALM Options

In order to generate output time series files for specific water quality parameters (in this case, they are named as *ec*, *turb*, *siva* and *norm*), tick the 'Save' check box against these parameters. Note that in *Run::Setup::Output* (Section 6.5.5), only 'Water quality data' under 'Reservoir' and 'Carrier' categories can be selected for output, and not the specific water quality parameters. These water quality parameters can be selected for output in Figure 4-13. If the log filename is entered as '*test.log*' (Section 6.2.1), only 'Reservoir' is selected for output in 'Water quality data' (Section 6.5.5), and all water quality parameters are requested to be 'saved' as in Figure 4-13, then four files, namely *Testec.rv*, *Testturb.rv*, *Testsiva.rv* and *Testnorm.rv* will be created as output files during the REALM simulation.

4.5 REALM UTILITY PROGRAMS

There are several utility functions available in REALM. They are partitioned in REALM Program Manager into two groups, as follows:

- Plot
- Filter
- Rank
- Format Conversion
- Calculator
- Merger
- Replicate Analysis
- LP Solver
- LP Extract
- Streamflow Transformation
- Data Base Extraction

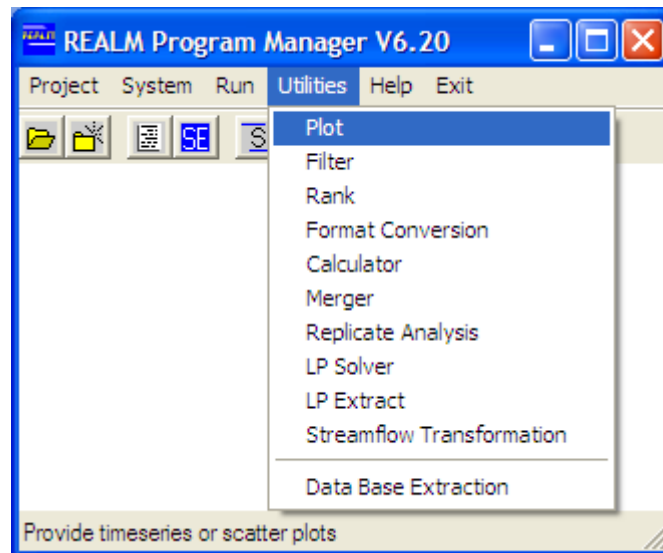



Figure 4-14 Utilities Menu

4.5.1 PLOT

This is a general purpose plotting utility, which provides graphical access to data of REALM format files. The REALM format files are streamflow, demand and output files, which have time series data. REALM Plotting can be accessed through the *Utilities::Plot* menu item or the  'Plotting routines' button of the REALM Program Manager (Figure 4-1). The details of the REALM Plotting utility are given in Section 8.1.

4.5.2 FILTER

This utility can be used to transfer or filter certain data from a REALM format file to create a smaller REALM format file. Two options exist namely filtering by numerical values, or filtering by months. Filter can be accessed through the *Utilities::Filter* menu item of the REALM Program Manager (Figure 4-1). The function of this utility is explained in Section 8.2.

4.5.3 RANK

This utility allows the user to rank any selected data columns of a REALM format file from highest to lowest. Rank can be accessed through the *Utilities::Rank* menu item of the REALM Program Manager (Figure 4-1). The function of this utility is explained in Section 8.3.

4.5.4 FORMAT CONVERSION

Format conversion provides a facility for converting one column of a standard REALM time series file into a "matrix" of values. It also provides a facility to change the field width of selected columns. Format conversion can be accessed through the *Utilities::Format conversion* menu item of the REALM Program Manager (Figure 4-1). The function of this utility is explained in Section 8.4.

4.5.5 CALCULATOR

This utility allows new data columns to be created in REALM format files. These new data columns can be of constant value or new data can be created by manipulating (i.e. adding, subtracting, and multiplying or dividing) existing data columns.

Calculator can be accessed through the *Utilities::Calculator* menu item of the REALM Program Manager (Figure 4-1). The function of this utility is explained in Section 8.5.

4.5.6 MERGER

This utility allows REALM format data files to be merged to create a new REALM format file. Merger can be accessed through the *Utilities::Merger* menu item of the REALM Program Manager (Figure 4-1). The function of this utility is explained in Section 8.6.

4.5.7 REPLICATE ANALYSIS

This utility can be used to

- Extract one replicate at all sites, all replicates at one site and one replicate at one site;
- Compute monthly and annual statistics of the replicate data.

Replicate Analysis can be accessed through the *Utilities::Replicate Analysis* menu item of the REALM Program Manager (Figure 4-1). The function of this utility is explained in Section 8.7.

4.5.8 LP SOLVER

This utility can be used to identify the cause of infeasible solutions obtained in REALM using LP dumps. The LP dumps may be created when infeasible solutions occur with REALM. LP Solver can be accessed through the *Utilities::LP Solver* menu item of the REALM Program Manager (Figure 4-1). The function of this utility is explained in Section 8.9.

4.5.9 LP EXTRACT

This utility reads and extracts carrier capacity and flow data from the log file containing LP dumps. LP Extract can be accessed through the *Utilities::LP Extract* menu item of the REALM Program Manager (Figure 4-1). The function of this utility is explained in Section 8.10.

4.5.10 STREAMFLOW TRANSFORMATION

This utility allows the user to alter input flows, such that streamflow properties that occur in one period of the flow record are replicated throughout the entire flow record. The utility was developed to evaluate the effect of climate change on water resources modelling. Streamflow Transformation can be accessed through the *Utilities::Streamflow Transformation* menu item of the REALM Program Manager (Figure 4-1). The function of this utility is explained in Section 8.11.

4.5.11 DATA BASE EXTRACTION

This utility extracts the required REALM output results from a database of results created from a previous REALM run. The data base extraction utility can be accessed through the *Utilities::Data Base Extraction* menu item of the REALM Program Manager (Figure 4-1). The function of this utility is explained in Section 8.12.

4.5.12 HELP AND EXIT

The *Help* menu item of the REALM Program Manager (Figure 4-1) is partitioned as follows:

- General
- About
- View Licence

The *Help::General* menu item at this stage does not contain any help. The user is referred to REALM manuals for help. The manuals are listed below:


- REALM Getting Started Manual (VU/DSE, 2005)
- REALM User Manual (VU/DSE, 2012)
- REALM Worked Examples Manual (VU/DSE, 2005).

The *Help::About* menu item shows the details of contact persons for:

- REALM use and license (**Note that this person may also be contacted for copies of any of the technical papers mentioned in this User Manual.**)
- REALM support and maintenance
- PRIDE use and license.

In addition, it acknowledges the REALM program development by the original developer and the Windows conversion.

The *Help::View Licence* menu item contains a copy of the Licence Agreement. [The user must agree to the terms of this agreement to successfully install the REALM software.]

The *Exit* menu item or the  'Exit program' button of the REALM Program Manager (Figure 4-1) allows the user to quit the REALM session.

Chapter 5

5 SYSTEM EDITOR (SE)

5.1 GETTING STARTED

In order to undertake modelling tasks with REALM, a file describing the elements of the water supply system must be assembled. This file is called a “system file” in REALM. The system file consists of:

- Nodes (reservoirs, demands etc.)
- Carriers (pipes and channels)
- Operating rules (restriction rules and target storage curves).

The System Editor (SE) assembles the system details according to the required format. It can be used for both creating a new file and editing an existing file. The System Editor has a graphical interface, enabling the user to construct a diagrammatic representation of both the physical attributes of the water-supply system (e.g. reservoirs, pipes) and the operating rules.

To open the System Editor:

Click on the *System::REALM System Editor* menu item of REALM Program Manager **or**

Click on the  ‘Run REALM System Editor’ button on the toolbar.

The REALM System Editor window (Figure 5-1) is displayed. Initially a message ‘No system file loaded’ will appear in the status bar (as shown in Figure 5-1) and all the tool buttons in the toolbar (as well as the menu items) will be inactive. Figure 5-2 shows the buttons on the toolbar.

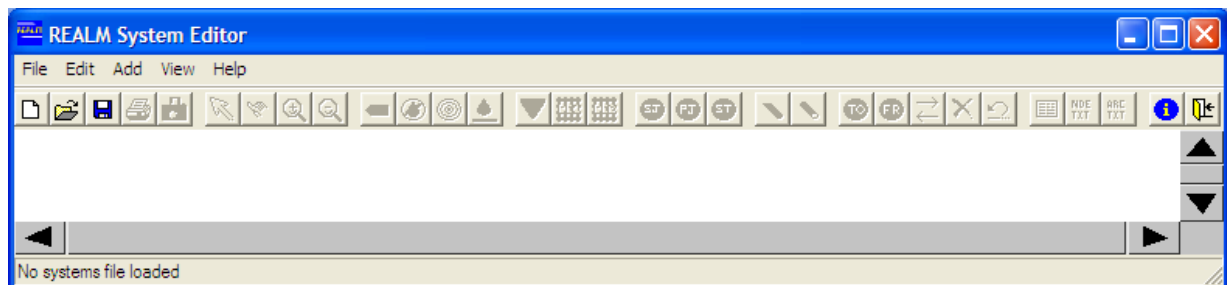




























Figure 5-1 REALM System Editor Window

	Create a new REALM system
	Open a REALM format file(s)
	Save a REALM system file
	Print REALM system file
	Print system to file
	Select and Edit a node or a carrier
	Select and move a node or a carrier
	Zoom in
	Zoom out
	Edit the system file label
	Edit restrictions
	Edit targets
	Edit spill groups
	Add a reservoir node
	Add an urban demand node
	Add a rural demand node
	Add a stream junction node
	Add a pipe junction node
	Add a stream terminator node
	Add a river carrier
	Add a pipe carrier
	Change the destination node of a carrier
	Change the node from which a carrier originates
	Change demand node type
	Delete a node or a carrier
	Undo all actions up to and including last delete action

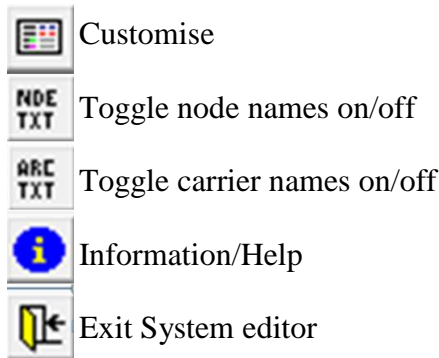


Figure 5-2 List of Buttons on the Toolbar

5.2 WORKING IN THE SYSTEM EDITOR

This section provides some tips on the functions available for working efficiently in the System Editor.

5.2.1 COPY AND PASTE:

This function copies and pastes the attributes of an **existing** node/carrier onto another **existing** node/carrier.

Copy and paste only works for like elements. For example, the attributes of one urban demand node can be pasted onto another urban demand node, but cannot be pasted onto a rural demand node.

When the attributes of one node/carrier (“element A”) are copied and pasted onto another (“element B”), the unique identifiers of element B (i.e. name, number and size) are not changed. For this reason, to check that a copy and paste has been successful, the user is advised to go into the “Edit” dialog box for the relevant node/carrier and examine the attributes of the node/carrier.

To copy and paste:

Click on the element (node or carrier) with attributes that are to be copied.

Right click on the mouse and select “Copy” **or**

Click on the *Edit::Copy* menu item.

Click on the element (node or carrier) with attributes to be modified.

Right click on the mouse and select “Paste” **or**

Click on the *Edit:: Paste* menu item.

Note that the standard keyboard shortcuts for cut and paste (i.e. ‘Control v’ and ‘Control c’) also can be used to perform these tasks.

5.2.2 FIND

Find is a useful function for locating carriers and nodes, particularly in large, complex models.

To find a carrier (or node):

Click on the *Edit::Find* menu item to display the “Find” dialog box (Figure 5-3).

Click on the ‘Carrier’ radio button. Note that at this stage, the drop down box contains a list of all the carriers in the model.

Enter the carrier name or part of the carrier name in the ‘Carrier Search:’ field. **The case (upper case or lower case) must match with the case of the carrier name.** Use * for wildcard. For example:

- *WERRIBEE returns all carrier names ending in WERRIBEE
- WERRIBEE* returns all carrier names starting with WERRIBEE
- *WERR* returns all carrier names with WERR somewhere in the name.

Click **Apply**. The list of carriers in the drop down box now shows only those carriers matching the search. Select the relevant carrier from the list in the drop down box and click **OK**. The user is returned to the System Editor window with the relevant carrier highlighted.

The process for finding a node is the same, except that the ‘Node’ radio button must be selected, and the search term is typed into the ‘Node Search:’ field.

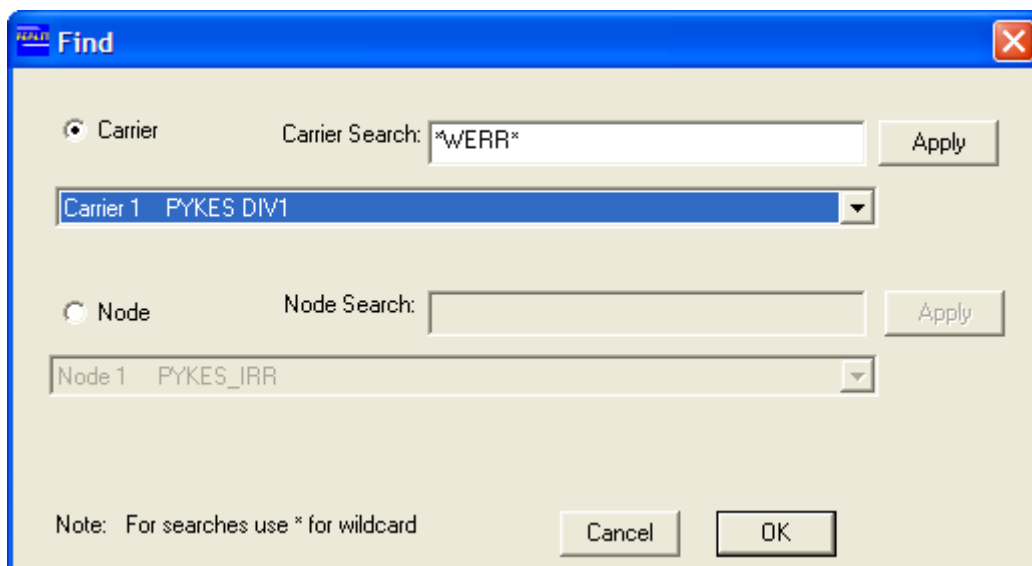


Figure 5-3 Find Dialog Box in System Editor

5.2.3 FUNCTIONS UNDER THE VIEW MENU

5.2.3.1 ZOOM IN/ZOOM OUT

To zoom in or zoom out:

Click on the *View::Zoom In* or *View::Zoom Out* menu item **or**

Click on the ‘Zoom in’ or ‘Zoom out’ button  on the System Editor toolbar **or**

Scroll up with the mouse to zoom in/ scroll down with the mouse to zoom out.

5.2.3.2 RESCALE

The Rescale function allows the user to rescale the location of every node and carrier towards the centre of the screen. This allows additional space to be created around the outer edges of the window to add more nodes or carriers if desired. However, this function should be used with caution: too many rescales can result in the schematic of the water system appearing cramped. The *'Undo all actions up to and including last delete action'* button **cannot** be used to reverse a rescale.

To rescale:

Click on the *View::Rescale* menu item.

5.2.3.3 BACKGROUND IMAGE/MANAGE BACKGROUND

These options are intended to allow the user to overlay a REALM schematic of a water-supply system over a background map/picture of that system. Background Image and Manage Background are not functional in REALM at this time.

5.2.3.4 CUSTOMISE VIEW

Customise View enables the user to change the appearance (colour, pattern, size, label) of elements (nodes/carriers) displayed in the System Editor graphical interface. Note that the appearance of a class of elements can be altered (e.g. all reservoirs nodes), but a single element (e.g. a reservoir) cannot be made to appear different to all other elements of that class.

To change the appearance of elements:

Click on the *View::Customise* menu item **or**

Click on the *'Customise'* button  on the System Editor toolbar.

The "Color Management" dialog box is displayed (Figure 5-4).

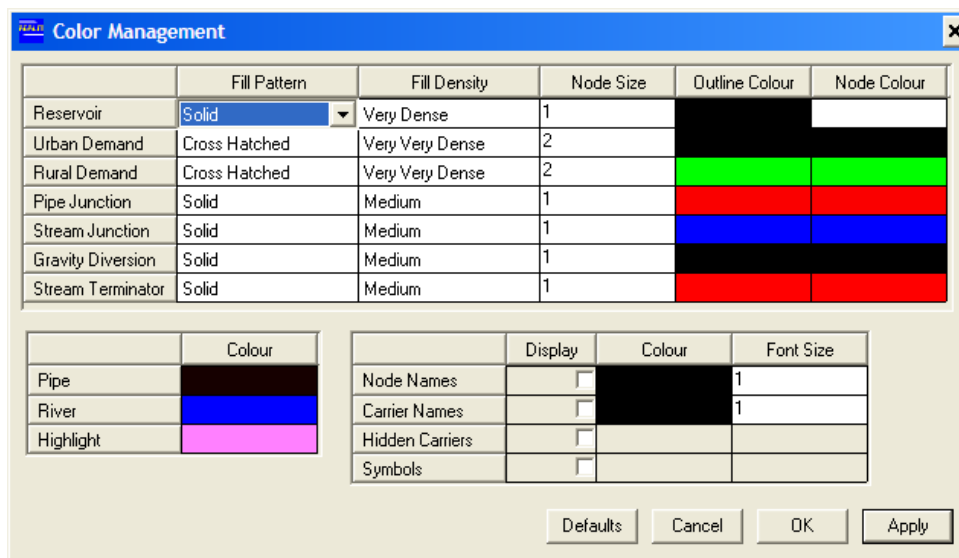


Figure 5-4 Color Management Dialog Box in System Editor

The first table in the dialog box lists all the types of node available in the graphical interface (e.g. “Reservoir”). The columns ‘Fill Pattern’, ‘Fill Density’, ‘Node Size’, ‘Outline Colour’ and ‘Node Colour’ are populated with default appearance attributes. To change an attribute, click on the cell in the table to be altered. A drop down box with a list of choices will be displayed or, for colours, the “Color” dialog box will appear. Make a selection and click **Apply** to see how the change looks. Note that altering the field ‘Node Size’ will make all the nodes of a particular type larger or smaller. However, if the user has individually specified that some nodes of that type are larger or smaller than others, the **relative** size of each node will not change.

Click **Defaults** to restore the default appearance settings at any time. Clicking **OK** returns the user to the System Editor window.

The second table in the “Color Management” dialog box shows the colour of each type of carrier (i.e. “Pipe” and “River”). The same process as for nodes may be followed to change the appearance of carriers. Note that the element “Highlight” simply refers to the colour that nodes and carriers turn when selected for editing (lilac in Figure 5-4).


The third table in the “Color Management” dialog box controls the appearance of text labels for nodes and carriers. Click on the relevant check box(es) in the ‘Display’ column to display the names of all the nodes or carriers. [Note that “Hidden Carriers” refers to the rarely used option in REALM to hide carriers from display by starting the carrier name with a colon. “Symbols” has no function in the current version of REALM.] The colour and size of the font may be altered by clicking on the relevant cell.

5.3 SYSTEM FILES

5.3.1 CREATING A NEW SYSTEM FILE

To create a new system file:

Click on the *File::New* menu item (Figure 5-5) **or**

Click on the  'Create a new REALM system' button on the toolbar of the System Editor.

When a new system file is being created all the tool buttons on the toolbar and all the options in the menu system will be active and functioning. The status bar will show a message 'Edit Network' on the right compartment.


At this stage, it is recommended that the user saves this file by giving it a descriptive filename, as described in Section 5.3.3.

5.3.2 EDITING AN EXISTING SYSTEM FILE

There are two methods to edit an existing system file:

Method 1:

Click on the menu item *File::Open* (Figure 5-5) **or**

Click on the  'Open a REALM System file' button from the toolbar.

This opens the standard file browsing dialog box.

Locate the required file and click on the **Open** button or double click on the file.

Method 2: If the system file to be edited is one of the four most recently used files

Click on the menu item *File* which will display the names and the paths of the four most recently used REALM system files at the bottom part of the *File* menu as shown in Figure 5-5.

Click on the appropriate file to open it with the System Editor.

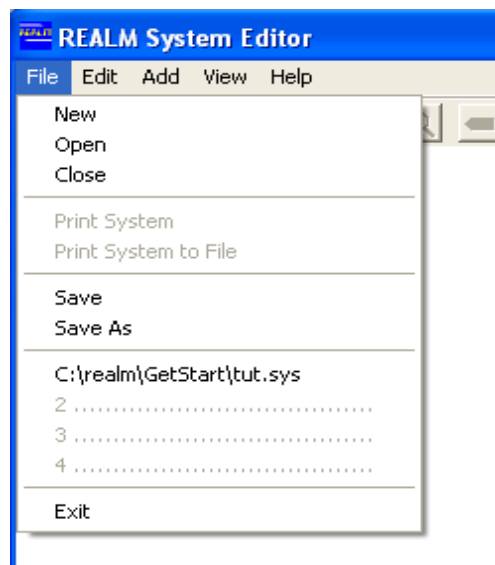


Figure 5-5 System Editor File Menu

5.3.3 SAVING A SYSTEM FILE

To save a system file:

For a newly created file, click on the *File::Save As* menu item, browse to where the file is to be saved and enter a descriptive filename.

For an existing file, click on the *File::Save* menu item **or**

Click on the  'Save a REALM system file' button.


To save an existing file under a different filename, select the *File::Save As* menu option.

5.3.4 PRINTING A SYSTEM FILE

There are two options for printing a system file:

To print a hardcopy of a system file:

Click on menu item *File::Print* **or**

Click on the  'Print REALM system file' button on the toolbar.


A standard "Page Setup" dialog box will appear.

To locate a network printer, click on the **Printer** button and, in the next dialog box, click on the **Network** button to browse through the network to the appropriate printer.

Click **OK** to print. If **Cancel** is clicked then the user will be returned to SE without printing.

To print a soft copy of a system file:

Click on the menu item *File::Print System to File* to create a graphic of the system file **or**

Click on the  'Print System to File' button on the toolbar.

Select the file type from the combo box. (Choose from the following standard image file types: Windows Metafile, CGM, Bitmap, Postscript or HPGL.)

The image file created can be viewed or printed by standard Windows image viewer programs.

5.4 NODES**5.4.1 CREATING/EDITING NODES**

Six different types of nodes are available for modelling water supply systems. They are represented by the items in the *Add* menu, as well as by the buttons on the toolbar shown in Figure 5-6.

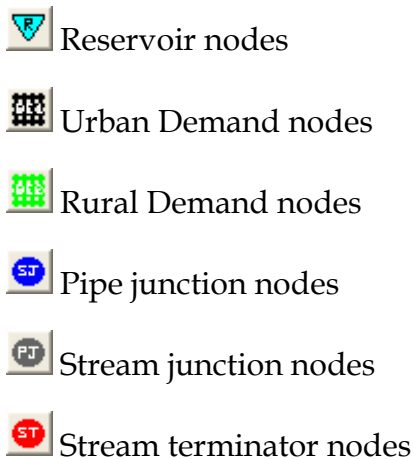


Figure 5-6 System Editor Add Menu

To create a node:

Click on the appropriate node button on the toolbar **or**

Select the appropriate node type from the *Add* menu.

The mouse pointer will change to an appropriate shape.

Click on the workspace.

Enter the relevant node parameters in the "Add node" dialog box that appears. Figure 5-7 shows this dialog box for a reservoir node.

Click on the **OK** button to make this node visible in the workspace.

Once the node is created, click on the  'Select and edit a node or a carrier' button to return to normal SE mode.

To edit a node:

Click on the  'Select and edit a node or a carrier' button.

Double click on the node to be edited **or**

Click the right mouse button on the node to be edited, then select "Edit".

Edit the relevant parameter(s) in the "Edit node" dialog box.

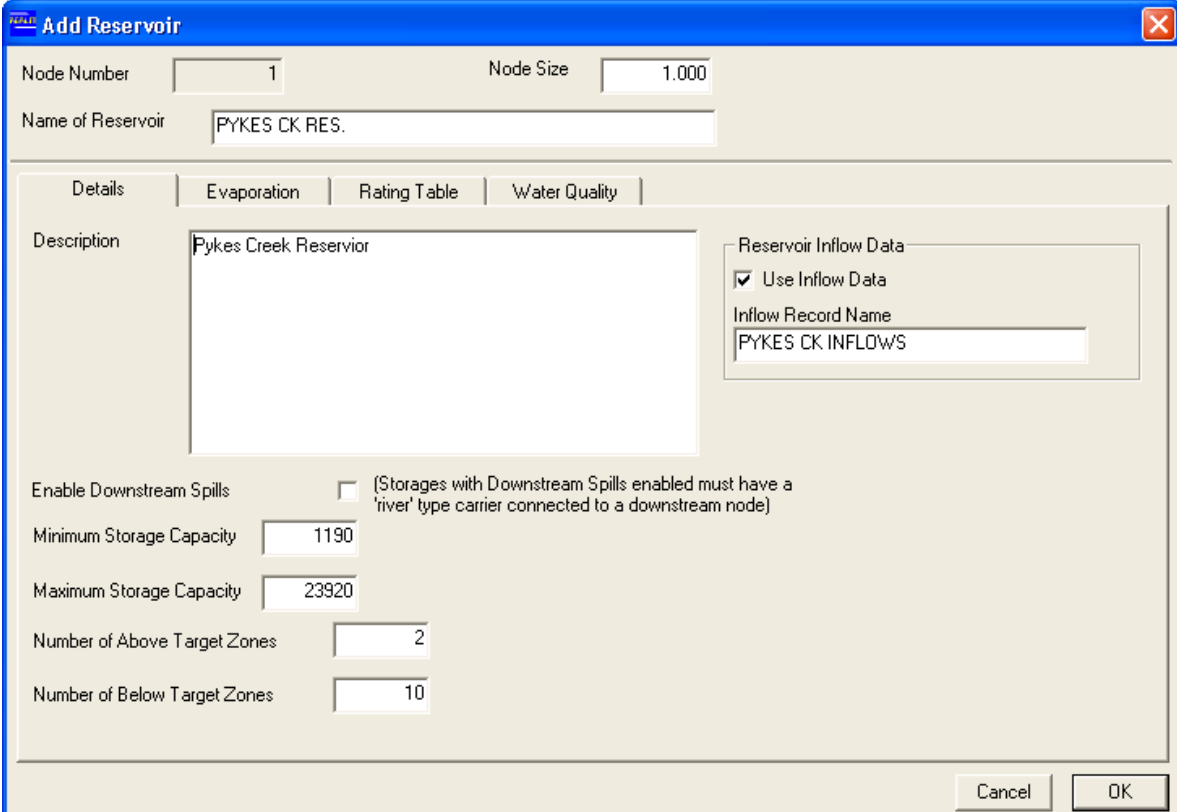




Figure 5-7 Add Reservoir Dialog Box

5.4.2 MOVING NODES

Sometimes it is necessary to move a node to a different location to avoid congestion of nodes and carriers in the network screen.


To move a node, click on the  'Select and move a node or a carrier' button. The mouse pointer will be changed to the  hand.

Click on the node and drag it to the desired position. All carriers connected to this node will also move accordingly.


Once the node is moved, click on the  'Select and edit a node or a carrier' button to return to normal SE mode.

5.4.3 DELETING/UNDELETING NODES

To delete a node:

Click on the  'Delete a node or carrier' button **or**

Select the menu item *Edit::Delete carrier/node*.


The mouse pointer will turn into an eraser .

Position the left edge of the mouse pointer over the particular node to be deleted and click.

A popup message box will appear to confirm the deletion.

Click **YES** to delete the node or **NO** button to return to the SE without deleting the node.

To undelete a node:

Click on the  'Undo all actions up to and including last delete action' button **or**

Select the menu item *Edit::Undo Delete*.

Note that when the user acquires a deleted node, all the changes made after deleting this particular node will also be reversed and removed.

5.4.4 RESERVOIR NODE (R)

The reservoir node represents a storage, which stores water from its natural catchments and/or receives water from other components of the water supply system. The storage releases water to meet demands, makes inter-reservoir transfers, meets environmental flow requirements and allows spills. All parameters and characteristics of a reservoir can be entered in the "Add Reservoir" dialog box (Figure 5-7), which is displayed at the time of creation of the reservoir. (Note that the header on the dialog box changes to "Edit Reservoir" once the new reservoir has been added.) Descriptions of the fields in the "Add Reservoir"/ "Edit Reservoir" dialog box are provided in the following sections.

5.4.4.1 BASIC PROPERTIES

Three basic properties define the reservoir node as unique identifiable object in the system, as described below.

Node Number

This is an auto-generated number to identify the node in the system file. The user has no control over this field.

Node Size

Node size gives a perspective view to the system. This is a scale between 0.1 and 10.0. It sets the size of the node displayed on the workspace. If a larger node is required, the user can select a higher value, and vice-versa for a smaller node. This information does not have an impact on the simulation.

Name of Reservoir

The reservoir node name should be entered in the text field '*Name of Reservoir*'. It is advisable to use a meaningful name for the node. This name is used in collating the output. An error message '*Duplicate node name (1st 15 chars)*' is displayed on the screen if a node name that has been previously used is entered.

5.4.4.2 RESERVOIR DETAILS

The basic details of the reservoir node can be entered in the "Details" tab of the "Edit Reservoir" dialog box, under the fields described below. Note that the "Details" tab is the default.

Description

An optional comment can be entered in this field describing the reservoir. This information does not have an impact on the simulation.

Reservoir Inflow Data

Tick the '*Use Inflow Data*' check box in the "Reservoir Inflow Data" block if the reservoir receives local inflow from its catchments. In this case, the '*Inflow Record Name*' field become active and the user is required to enter the **Inflow Record Name, which should be a streamflow data column name of a streamflow file used in the REALM application**. This name should be correctly spelled (including the case) as the column name in the streamflow file. If the reservoir does not receive local inflow, the check box '*Use Inflow Data*' should be left blank.

Enable Downstream Spills

This option specifies whether or not the reservoir can spill. If the '*Enable Downstream Spills*' check box is ticked, REALM determines whether the spills from this reservoir are used downstream or lost from the system, based on the presence of river carrier(s) immediately downstream of the reservoir node. If a river carrier is present, spills are used by the downstream components of the system. If no river carrier is present, spills are lost externally.

If the check box is not ticked for the spill option, then the spills occur elsewhere in the system. The non-spilling option should be selected only for off-stream storages, which receive water transfers from other reservoirs. The non-spilling option ensures that this reservoir does not spill, and limits the water transfers from other reservoirs to this reservoir.

Minimum Storage Capacity and Maximum Storage Capacity

Minimum and maximum storage capacities of the reservoir are entered here. Minimum generally represents dead storage and maximum generally represents capacity.

Number of Above/Below Target Zones

Enter the number of above and below target zones of the reservoir in these fields separately.

The above and below target zones determine how water is allocated from a reservoir when it does not meet the target defined by the reservoir targets (Section 5.8). These zones are used in REALM with the reservoir drawdown priority defined under the *Edit::Targets* menu item in the System Editor window (Section 5.8). Different or the

same number of above/below target zones can be assigned to different reservoirs.

If two or more reservoirs go below target to satisfy the required demand, then the below target zones (together with reservoir drawdown priority) of these reservoirs are used to allocate the water transfers. The storage volume between the reservoir target and the minimum storage volume of each reservoir that goes below target is divided into zones based on the number of below target zones. First, the reservoir with the drawdown priority of the lowest number uses first zone to supply the demand. If the demand is not fully supplied, then the first zone of the reservoir with the drawdown priority of the next-lowest number is used. This procedure is used until the first zone of all reservoirs is used or the demand is fully satisfied, whichever reaches first. If the demand is not fully met still, then the second zone (if exists) of the reservoir with the drawdown priority of the lowest number is used again and so on. The procedure is repeated until the demand is fully met.

The same logic applies to the above target zones. In this case, the number of zones is defined based on the storage volume between the maximum capacity and the reservoir target. If two or more reservoirs go above target, the first zone of the reservoir with the drawdown priority of the highest number is recharged, followed by the first zone of the reservoir with the drawdown priority of the next-highest number and so on. The procedure is similar to the case of below targets and is followed until excess water above targets is used to recharge the above target reservoirs.

5.4.4.3 RESERVOIR EVAPORATION

Loss of water from reservoirs can be significant in the overall balance of water in the water supply system. Losses can be evaporation and/or seepage. Rainfall falling on the reservoir increases its volume. These losses and gains can be modelled via reservoir evaporation in the reservoir node.

These losses/gains are modelled in REALM as a linear equation, as shown in Equations 5.1 and 5.2.

Where

$$\text{Evaporation (mm)} = B * (\text{Evaporation Data}) + A - (\text{Rainfall Data}) \quad 5.1$$

$$\text{Net Evaporation (ML)} = \text{Evaporation (mm)} * \text{Surface Area(Ha)} / 100 \quad 5.2$$

B - Pan Evaporation Factor

A - Adjustment Factor

The loss or gain of water in the reservoir is computed using coefficients A and B, evaporation and rainfall data, and surface area corresponding to the storage volume of the reservoir at the beginning of the simulation time step. Evaporation and/or seepage loss can be considered to be modelled through the “B*(Evaporation Data) + A” component of Equation 5.1, while the gain of water in the reservoir is modelled via the rainfall data. Evaporation data do not have to be strictly evaporation. They can be temperature, which can be converted to compute the losses via the coefficients A and B. Rainfall data can be from a nearby rain gauging station.

Parameters required for calculating the evaporation loss for the reservoir have to be entered in the “Evaporation” tab of the “Edit Reservoir” dialog box (Figure 5-8). Note

that initially the “Evaporation” tab does not contain any data, and this should remain the case if the user does not wish to model evaporation losses of the reservoir.

Evaporation Record Name

This is a column name in a streamflow data file (usually pan evaporation or temperature) used in the REALM application, which will be used to compute the evaporation losses in the reservoir, if evaporation is considered. This name should be correctly spelled (including the case) as the column name given in the streamflow file.

Rainfall Record Name

This is a column name of rainfall data in a streamflow data file used in the REALM application, which is used to compute the rainfall gain in the reservoir, if rainfall is to be considered. This name should be correctly spelled (including the case) as the column name given in the streamflow file.

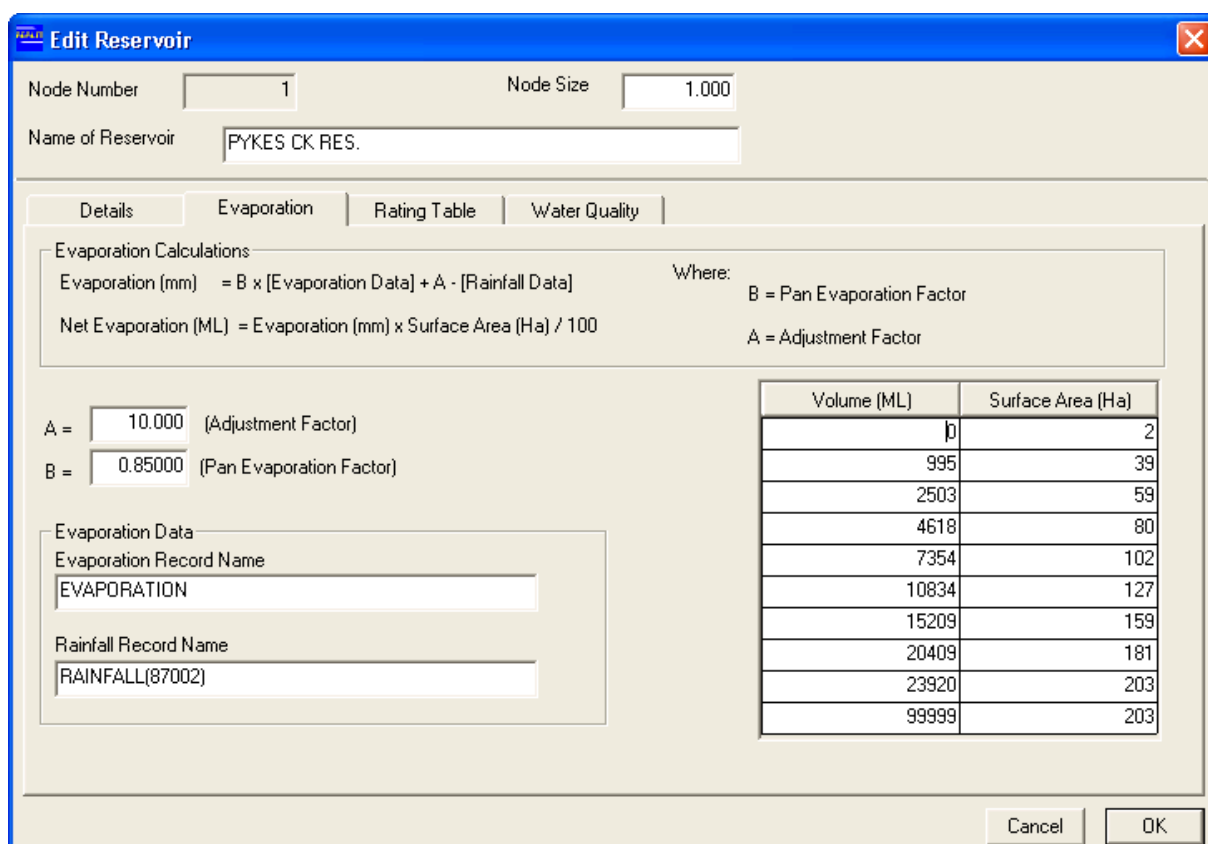


Figure 5-8 Evaporation Tab of Reservoir Node

Different reservoir nodes can have different evaporation/rainfall record combinations, but these record names **should** appear as column names in streamflow files, which are used in the REALM application.

Coefficients A and B

These coefficients are generally determined by regression of available data for actual evaporation against the proxy variable (usually pan evaporation or temperature).

Volume-Surface Area Relationship

The volume-surface area relationship is entered here. The values for storage volume should range from 0 to the maximum capacity of the reservoir. The storage volume and surface area are expressed in ML and ha respectively.

Net evaporation (ML) during a simulation time step is determined by multiplying the evaporation (mm) computed from Equation 5.1 by the surface area (ha) as in Equation 5.2; the surface area is computed from the volume-surface area relationship corresponding to the storage volume at the start of the simulation time step.

5.4.4.4 RESERVOIR RATING TABLE

REALM produces the storage volumes at the end of simulation time step in ML. However, these storage volumes can be converted to water levels by entering the storage volume and water level relationship in the “Rating Table” tab of the “Edit Reservoir” dialog box (Figure 5-9).

In this table, the storage volume is expressed in ML and the corresponding storage level is expressed in m with respect to a certain datum.

The screenshot shows the 'Edit Reservoir' dialog box with the 'Rating Table' tab selected. The 'Name of Reservoir' is 'PYKES CK RES.'. The table below shows the 'Reservoir Rating Table (Stage Storage Relationship)' with 13 rows. Each row has a 'Volume (ML)' column and a 'Reduced Level (mAHd)' column, both containing the value '0'.

	Volume (ML)	Reduced Level (mAHd)
1	0	0.000
2	0	0.000
3	0	0.000
4	0	0.000
5	0	0.000
6	0	0.000
7	0	0.000
8	0	0.000
9	0	0.000
10	0	0.000
11	0	0.000
12	0	0.000
13	0	0.000

Figure 5-9 Rating Table Tab of Edit Reservoir Dialog Box

5.4.4.5 RESERVOIR WATER QUALITY PARAMETERS

Water quality parameters can be modelled by entering data in the “Water Quality” tab of the “Edit Reservoir” dialog box (Figure 5-10). Four water quality parameters can be modelled with the current version of REALM. They are shown as *ec*, *turb*, *siva* and *norm* in Figure 5-10, but can be changed using the “Water Quality” tab of the *Run::Options* menu item.

Water quality input can be entered as a fixed concentration or a variable concentration (which varies throughout the simulation period). Concentrations are in standard water quality units. If the concentration of particular water quality parameter is constant over the simulation period, then click on the ‘Fixed Concentration’ radio button and enter the value in the ‘Concentration=’ field. If the concentration varies during the simulation, then click on the ‘Variable Concentration from File’ radio button

and enter the Record Name in 'Record Name' field. This Record Name **should** be a column name in a streamflow file used in the REALM application describing concentration as a time series. The Record Name in this field **should** be spelled correctly (including the case) as in the streamflow file.


The '% Loss =' field allows the user to input the percentage loss of load of the water quality constituent, irrespective of water quality entered, as a fixed concentration or variable concentration. During a simulation time step, water quality load is reduced by this percentage. The '% Loss' can be used to model non-conservative water quality constituents, such as Biological Oxygen Demand (BOD).

Figure 5-10 Water Quality Tab of Edit Reservoir Dialog Box

5.5 DEMAND NODES

There are two types of demand nodes available in REALM, namely DC1 for modelling urban demands and DC2 for modelling irrigation or rural demands. They are similar from the viewpoint of water consumption. The major difference between DC1 and DC2 is the way the restrictions are imposed on these demands.

To change the type of a demand node:

A DC1 node can be changed to a DC2 node, and vice versa by selecting the *Edit::Change demand node type* menu item or clicking on the  'Change demand node type' button on the toolbar in the System Editor window. Then click on the demand node to be changed. A dialog box will appear asking the user to confirm the change. Click **Yes** to change the type of demand node or **No** to cancel. Note that when a DC2 node is converted to a DC1 node, some information (e.g. limit curve, carryover) may be lost.

5.5.1 URBAN DEMAND NODE (DC1)

The DC1 node represents an urban demand. This may include residential, industrial and institutional water demands, which consist of both in-house and outdoor consumption.

The “Add Urban Demand Centre” or “Edit Urban Demand Centre” dialog box will appear once the user creates a new urban demand centre or double-clicks on an existing urban demand centre or right-clicks on an existing urban demand centre. Note that these two dialog boxes are exactly the same, except the header. This dialog box is shown in Figure 5-11.

5.5.1.1 BASIC PROPERTIES

Three basic properties define the urban demand node as unique identifiable object in the system, as described below.

Node Number

This is an auto-generated number to identify the node in the system file. The user has no control over this field.

Node Size

This is a scale between 0.1 and 10.0. It sets the size of the node displayed on the workspace. If a larger node is required, the user can select a higher value, and vice-versa for a smaller node. This information does not have an impact on the simulation.

Name of Urban Demand Centre

The name of the urban demand centre should be entered in the ‘*Name of Urban Demand Centre*’ field, which should be the demand column name in a demand data file used in the REALM application. The name in this field should be correctly spelled (including the case) as the column name given in the demand file.

It is advisable to use a meaningful name for the node. This name is used in collating the output. An error message ‘*Duplicate node name (1st 15 chars)*’ is displayed on the screen if a node name that has been previously used is entered.

5.5.1.2 URBAN DEMAND NODE DETAILS

The basic details of the urban demand node can be entered in the “Details” tab under fields mentioned below. Note that the “Details” tab is the default.

Description

An optional comment can be entered in this field to describe the urban demand centre. This information does not have an impact on the simulation.

Node Number: 28 Node Size: 1.843

Name of Urban Demand Centre: HORSHAM URB

Details | Demand Modelling

Description: [Empty text area]

Demand Shortfall

Demand Shortfall Priority: 10

Number of Demand Shortfall Zones: 3

Annual to Monthly Disaggregation Factors

Enable editing of disaggregation factors

	Minimum	Maximum
January	0.000	0.000
February	0.000	0.000
March	0.000	0.000
April	0.000	0.000
May	0.000	0.000
June	0.000	0.000
July	0.000	0.000
August	0.000	0.000
September	0.000	0.000
October	0.000	0.000
November	0.000	0.000
December	0.000	1.000

Climate Index Record Name: [Empty text field]

Cancel OK

Figure 5-11 Edit Urban Demand Centre Dialog Box

Demand Shortfall Priority

The demand shortfall priority determines the order in which the demand nodes experience shortfalls (or failures) when two or more demand zones experience shortfalls. The shortfall priority (together with number of shortfall zones) distributes the demand shortfalls among the demand nodes. This shortfall distribution is discussed under the next heading of “Number of Demand Shortfall Zones”. The shortfalls are usually due to the capacity constraints of the system. Each demand zone should have a different shortfall priority to eliminate the ambiguity in sharing the shortfalls.

Number of Demand Shortfall Zones

Each demand is divided into a number of zones based on the number of shortfall zones. The demand shortfall priority is used in conjunction with the number of shortfall zones to determine the order in which demands experience shortfalls. Different or same number of shortfall zones can be assigned to different demand centres. Once the shortfall is computed by REALM corresponding to a set of demand centres which experiences shortfall, the first demand centre with the shortfall priority of lowest number experiences the shortfall to the size of its first zone. Then the demand node with the shortfall priority of second-lowest number experiences the shortfall to the size of its first zone and so on until the shortfall is distributed using the first zones of each demand centre. If the shortfall is distributed by first few demand centres, then the remaining demand centres do not experience any shortfalls. On the other hand, if the shortfall is not fully distributed yet, the second zones (if any in

certain demand centres) are considered as earlier. This procedure is repeated until the demand shortfalls are fully distributed among the demand centres, which experience shortfalls.

Annual to Monthly Disaggregation Factors

If annual demands are given in the demand file(s), they are converted to monthly values using the disaggregation factors entered here. The sum of the maximum factors must be exactly 1.0. Typically, the monthly disaggregation will follow a summer/winter trend with higher values in summer than in winter. The minimum factors represent the fractions used to compute the base monthly demand (typically household demand that cannot be restricted).

If monthly demands are given in the demand data file(s), these minimum and maximum aggregation factors are not used. However it is necessary that sum of the maximum factors should be 1.0 to continue with editing operations.

In order to edit and/or enter values for “Annual to Monthly Disaggregation Factors” and “Climate Index Record Name”, it is necessary to tick the ‘*Enable editing of disaggregation factors*’ check box.

Climate Index Record Name

The ‘*Climate Index Record Name*’ entry is used only when annual demand data is considered and is used to adjust monthly demands for climatic conditions, once the annual demand is disaggregated using monthly maximum disaggregation factors. The record name entered here should be a column name in a streamflow file used in the REALM application. This name should be spelled correctly (including the case) as given in the streamflow file.

The climatic variability of demands tends to be inversely proportional to the streamflow. It also may depend on a combination of rainfall, temperature and time of the year. Therefore, to include this dependence in REALM when annual demands are used, it is necessary to determine the influence of climatic variability externally and then to assemble the appropriate monthly information in the streamflow file. This climatic information in the file (generally known as a climatic index) should be greater than zero, while 100 indicates the average demand, which does not require any adjustment to climatic conditions.

The climatic index is then used as follows in REALM:

$$\text{Monthly Demand} = \frac{CI_j}{100} Y_j + j \quad 5.3$$

Where

Monthly Demand is the seasonally adjusted monthly demand,

j is the season number,

CI_j is the climatic index for the *j*th season,

Y_j is the difference between monthly demand generated by the annual demand (read from the demand file and disaggregated using monthly disaggregation

factors) and monthly base demand for the j^{th} season, and

B_j is the monthly base demand for the j^{th} season.

The seasonally not-adjusted monthly demand is computed by multiplying the annual demand by the maximum disaggregation factors. Similarly, the monthly base demand is computed by multiplying the annual demand by the minimum disaggregation factors. It is possible to have different climatic index variables for different DC1 nodes.

5.5.1.3 DEMAND MODELLING

Even though demand modelling is available for DC1 nodes, this function is not generally used. Demand modelling for DC1 nodes is the same as for DC2 nodes. Refer to Section 5.5.2.3.

5.5.2 IRRIGATION OR RURAL DEMAND NODE (DC2)

The DC2 node represents an irrigation or rural demand, where water is generally used for irrigation purposes. The DC1 and DC2 nodes are similar from the viewpoint of water consumption, but differ with respect to the imposition of restrictions. Water restrictions in DC1 nodes are determined through the urban restriction rule curves, while in DC2 nodes they are determined through the allocation and limit curves.

The major difference in the restriction philosophy is that with urban type demands (DC1), the restrictions apply to the demand of each month regardless of what has been supplied previously, and the severity of restrictions can increase or decrease throughout the year. With irrigation demands (DC2), the amount of restrictions of the current month is dependent on the annual volume of allocation of the irrigation season and the progressive supplies from the start of the irrigation season to the current season.

The dialog box shown in Figure 5-12 is displayed when an existing DC2 node in the system network is edited, enabling the user to edit the details of the DC2 node. Similarly, if the user wishes to create a DC2 node, a similar dialog box to Figure 5-12 (except the header) will appear.

5.5.2.1 BASIC PROPERTIES/DETAILS

The information required for the fields '*Node Number*', '*Node size*', '*Name of Rural Demand Centre*', '*Description*', and '*Demand Shortfall*' is similar to those of the Urban Demand Centre (DC1) nodes (Section 5.5.1).

Edit Rural Demand Centre

Node Number: Node Size:

Name of Rural Demand Centre:

Details | Limit Curve Based Restrictions | Carryover | Demand Modelling

Description:

Demand Shortfall

Demand shortfall priority:

Number of demand shortfall zones:

Cancel OK

Figure 5-12 Details Tab of Edit Rural Demand Centre Dialog Box

5.5.2.2 LIMIT CURVE BASED RESTRICTIONS

The “Limit Curve Based Restrictions” tab (Figure 5-13) is used to define the relationship between the “Percentage-announced” allocation and the total delivery to the end-of-season (*Limit*) for the demand node. The ‘*Fraction (%)*’ field specifies a percentage which determines the coefficients *a*, *b* and *c* of the limit curve equation (Equation 5.4). **The limit curve describes the cumulative restricted demand for different months during the irrigation season for a given percentage-announced allocation.**

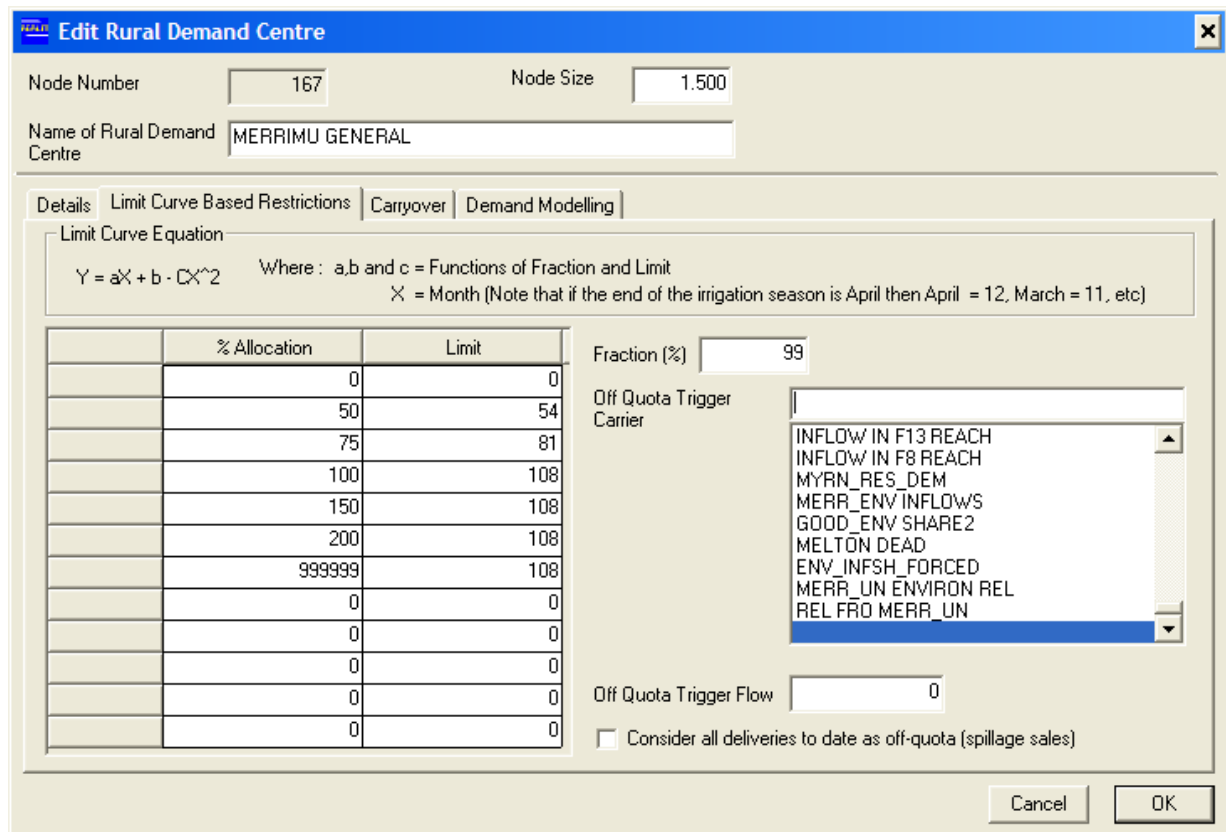


Figure 5-13 Limit Curve Based Restrictions Tab of Edit Rural Demand Centre Dialog Box

$$Y = a X + b - c X^2 \tag{5.4}$$

Where:

- Y is the cumulative restricted demand by the end of month X,
- X is the indicator (or a number) for month, which depends on the last month of the irrigation season (i.e. if the last month of the irrigation season is April, then April =12; March =11;; May = 1), and
- a, b, and c are functions of 'Limit' (which is computed from the percentage allocation-to-limit relationship of the demand node corresponding to the "announced" allocation) and 'Fraction (%)'.

Both the percentage "announced" allocation-to-limit relationship and the percentage fraction have to be determined from available irrigation data outside REALM. When recorded irrigation deliveries during the irrigation season are plotted against the allocation for different years, generally the plot takes the form of Figure 5-14. The percentage allocation-to-limit relationship is defined from this figure as the upper envelope curve, which gives the maximum total delivery for the irrigation season for different allocations.

The straight-line portion of the curve indicates that the utilisation of water is high (almost 100%). In this region, the "announced" allocation (converted to the amount of

water that can be used by this demand node) is fully utilised. Above 100% allocation, the rate of utilisation decreases, and the curve flattens.

For the case of the historical entitlement framework of the water right with sales, the amount of water that can be used is computed by multiplying the percentage allocation by the water right. The 100% allocation provides 100% water right as the amount of water that can be used. It can also be used for current framework of high and low reliability water share (HRWS and LRWS) entitlements; 0 to 100% allocation being for HRWS entitlements and 100 to 200% allocation for LRWS entitlements.

If the demand node is used to model the supply at an irrigation district offtake and there are delivery losses within the irrigation supply system, then the limit column in the above relationship should allow for the delivery efficiency of the irrigation area. Therefore, 100% allocation will produce a limit, which is higher than 100% HRWS entitlement. However, if the delivery losses are modelled as a loss in the supply carrier to the demand node, then 100% allocation should relate to the volume of entitlement within the irrigation area at 100% allocation.

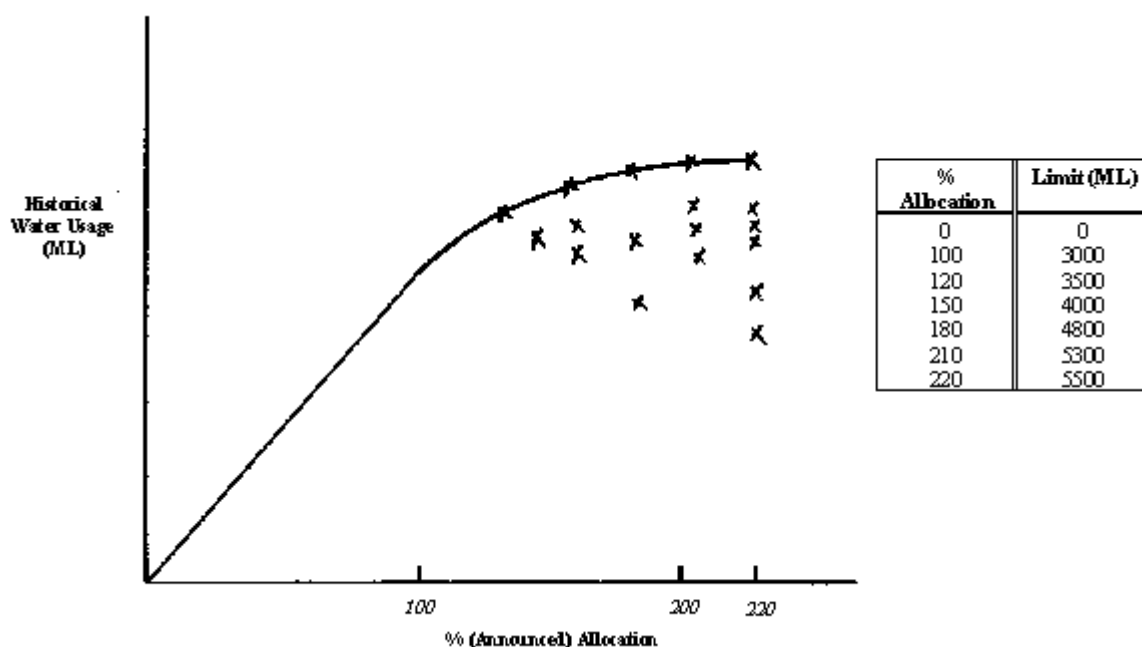


Figure 5-14 Development of Percentage Allocation – Limit Relationship

One other feature of irrigation deliveries (especially in pasture growing areas) is that the farmers do not generally restrict their irrigation deliveries until the middle of the irrigation season. This is because the allocation relates to a volume of entitlement for the whole irrigation season and it is economical to use the water early in the season and hope that the inflows will improve and the allocation will increase later in the irrigation season. For example, if the irrigation season is from August to April, the irrigation usage is generally not restricted until about December. This has to be reflected in modelling of irrigation restrictions. It is modelled through the limit curve equation (Equation 5.4), which determines the cumulative restricted demand from the start of the irrigation season to the current month, which is under consideration in REALM simulation.

As can be seen from Equation 5.4, the cumulative restricted demand is a function of

variable X which is defined based on the last month of the irrigation season. If the end of the irrigation season (or the last month of the irrigation season) is April, then May is considered as the start of the irrigation season (or $X = 1$), $X=2$ for June, $X=3$ for July, ..., $x=12$ for April for computational purposes in the limit curve equation (i.e. Equation 5.4). The shape of the curve represented by the parabolic equation defined by Equation 5.4 and generally follows the water usage pattern from (approximately) the middle of the irrigation season to the end of the season, as seen in Figure 5-15. The parameters a , b and c determine the cumulative restricted demand and are estimated from the maximum delivery for the irrigation season (*Limit*) and the percentage fraction (*fraction(%)*) from Equations 5.5–5.7

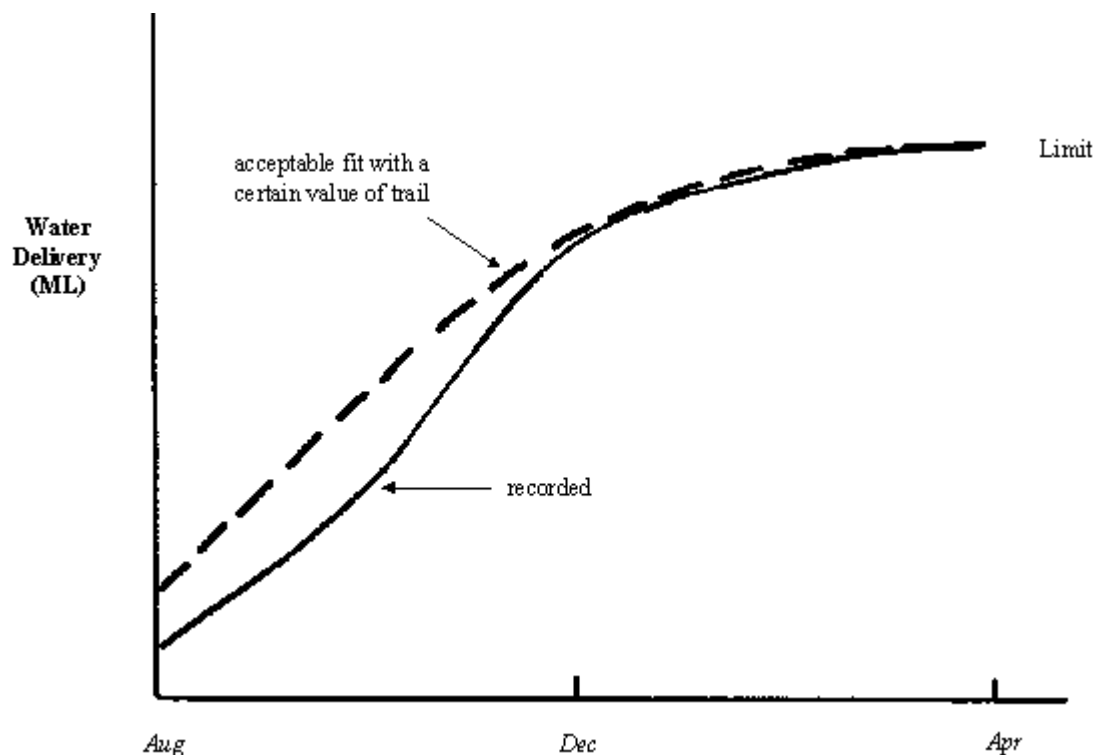


Figure 5-15 Typical Irrigation Delivery Curve and Curve Fitting

$$b = \text{Limit} * \frac{\text{Fraction}(\%)}{100} \quad 5.5$$

$$a = \frac{\text{Limit} - b}{6} \quad 5.6$$

$$c = \frac{a}{24} \quad 5.7$$

During the simulation, REALM calculates the *Limit* by interpolation using the values in the percentage allocation-to-limit relationship, once the allocation is computed in REALM.

The percentage fraction ($Fraction(\%)$) must be determined in the calibration phase in such a way that the restrictions do not occur in early part of the irrigation season. Low values of $Fraction(\%)$ may give early restrictions, which do not happen in practice. As a guide in determining $Fraction(\%)$, it is possible to analyse the irrigation delivery records for the year which had the maximum delivery and determine $Fraction(\%)$ by trial and error, in such a way that it reflects the water usage in that year. The *Limit* is known for this year, which is the total delivery for irrigation season. Several values of $Fraction(\%)$ in the limit equation can be considered by trial and error, so that the deliveries in the early months of the irrigation season (i.e. during unrestricted period) is fully supplied and the restricted demand is supplied during the restricted period. A $Fraction(\%)$ value of 30% has been used when simulating the demands in the Goulburn/Murray irrigation system and as a guide, this value can be used, if no other values are available.

As stated earlier, in REALM, the limit curve equation (i.e. Equation 5.4) computes the cumulative restricted demand from start of the irrigation season to the end of the current month for the (“announced”) allocation. The restricted demand for the current month is then computed as the difference between the above cumulative demand and the demand supplied so far during the irrigation season (up to the current month).

For the irrigation areas with different types of crops, both the percentage allocation-to-limit relationship and the percentage fraction should be determined appropriately from the available irrigation delivery data.

Supply of Off Quota water

The “Limit Curve Based Restrictions” tab also provides the option to model off quota water deliveries. The off quota deliveries are supplied during times of excess water in certain parts of the system and can be used by this DC2 node. Generally, this excess water cannot be stored in the system. Off quota water used by this demand node is not taken into consideration when restrictions are imposed. That is, off quota water is not considered as part of the demand supplied in computing the restricted demand. The off quota supplies are triggered in REALM when the flow in ‘Off Quota Trigger Carrier’ is greater than the ‘Off Quota Trigger Flow’. The ‘Off Quota Trigger Carrier’ can be a fixed or a variable capacity carrier.

Spillage sales refers to a situation used in some water-supply systems where supply-to-date during the season is reset to zero if an offquota event occurs. For example, an irrigator with an allocation of 100 ML may divert say 40 ML, after which an off-quota event occurs. Normally the irrigator can then only divert the remaining 60 ML of their allocation to the end of the season. Under spillage sales rules, the allocation reverts to 100 ML.

To turn on spillage sales rules, click the ‘Consider all deliveries to date as off-quota (spillage sales)’ box in the rural demand centre node window (Figure 5-13).

5.5.2.3 DEMAND MODELLING

This section describes how to enter parameters and setup PRIDE models within urban (DC1) and rural (DC2) demands in REALM. PRIDE (Program for Regional Irrigation Demand Estimation) estimates irrigation demand by using a combination of climate data, crop culture and knowledge of traditional farming practices. The PRIDE User Manual details the PRIDE algorithm and the technical background to PRIDE, and may be downloaded by following the instructions under Section 1.5.3.

The user can set up an irrigation demand model at a demand centre node by clicking on the “Demand Modelling” tab. This displays the dialog box shown in Figure 5-16.

The screenshot shows a dialog box titled "Edit Urban Demand Centre". At the top, there are two input fields: "Node Number" with the value "24" and "Node Size" with the value "0.922". Below these is a text field for "Name of Urban Demand Centre" containing "HORSHAM PRIDE". The dialog has two tabs: "Details" and "Demand Modelling", with the latter being the active tab. Under the "Demand Modelling" tab, there is a checked checkbox labeled "Use a model to calculate unrestricted demand at this node?". Below this checkbox is a dropdown menu for "Demand Model" which currently shows "1. PRIDE version w2.0 (Current)". Underneath the dropdown is a button labeled "Edit Model Parameters". At the bottom right of the dialog are two buttons: "Cancel" and "OK".

Figure 5-16 Demand Modelling Tab of Edit Rural Demand Centre Dialog Box

To activate an irrigation demand model for the demand centre node, select the ‘Use a model to calculate unrestricted demand at this node’ check box. This activates the other fields in this dialog box. Under the “Demand Model” drop down box there are a number of choices of different models available to calculate unrestricted demand at the node. Depending on the model selected, the options available when the user clicks the ‘Edit Model Parameters’ button will vary.

PRIDE Version w2.0 and PRIDE Version w1.1

Selecting either PRIDE version w2.0 or w1.1 in the “Demand Model” drop down box and then clicking the ‘Edit Model Parameters’ button produces the dialog box shown in Figure 5-17. There are six tabs which must be completed to enter the PRIDE model parameters.

The screenshot shows the 'PRIDE Parameters' dialog box with the 'Model Setup' tab selected. The 'Climate Data' section contains the following fields:

Field Name	Value	Fraction
Evaporation Data Timeseries	EVAP 79028	
Rainfall Data Timeseries (1)	RAIN 79028	0.50000
<input checked="" type="checkbox"/> Rainfall Data Timeseries (2)	RAIN 79023	0.50000
<input type="checkbox"/> Rainfall Data Timeseries (3)		0.00000

Figure 5-17 Model Setup Tab of PRIDE Model Parameters Dialog Box

Model Setup

Under the “Model Setup” tab (Figure 5-17), enter the climate data to be used for the model run.

In the ‘*Evaporation Data Timeseries*’ field, enter a name corresponding with the column name of an evaporation data timeseries in the crop model input files. Note that a column name in one of the streamflow or demand files will not be recognised for input into a PRIDE model. Similarly, column names in the crop model input files cannot be referenced in carriers or other locations.

As per the standalone version of PRIDE, the user has the option to enter up to three rainfall data timeseries. The first timeseries name is specified in the ‘*Rainfall Data Timeseries (1)*’ field. If a second timeseries is to be used, tick the ‘*Rainfall Data Timeseries (2)*’ check box and enter the appropriate column name. If multiple rainfall timeseries are used, the ‘*Fraction*’ fields should be filled out. Note that the sum of the rainfall timeseries fractions must add to 1.

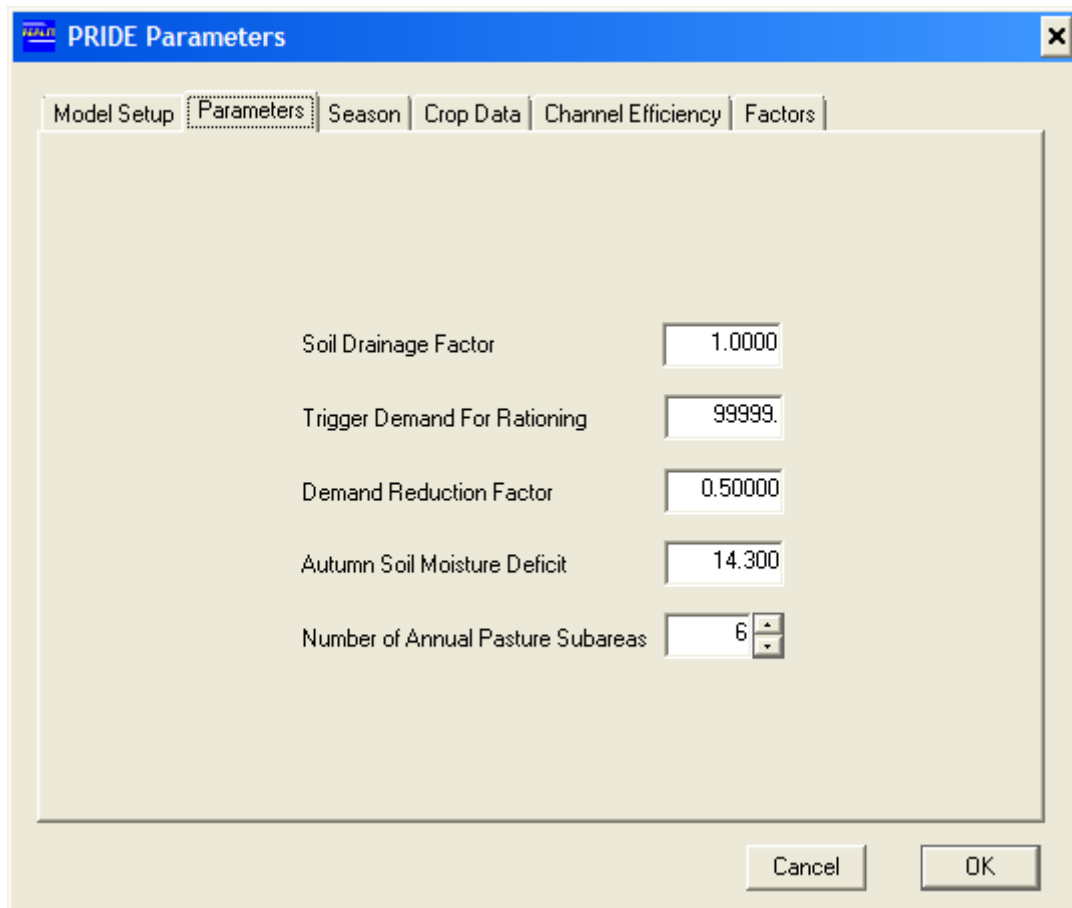
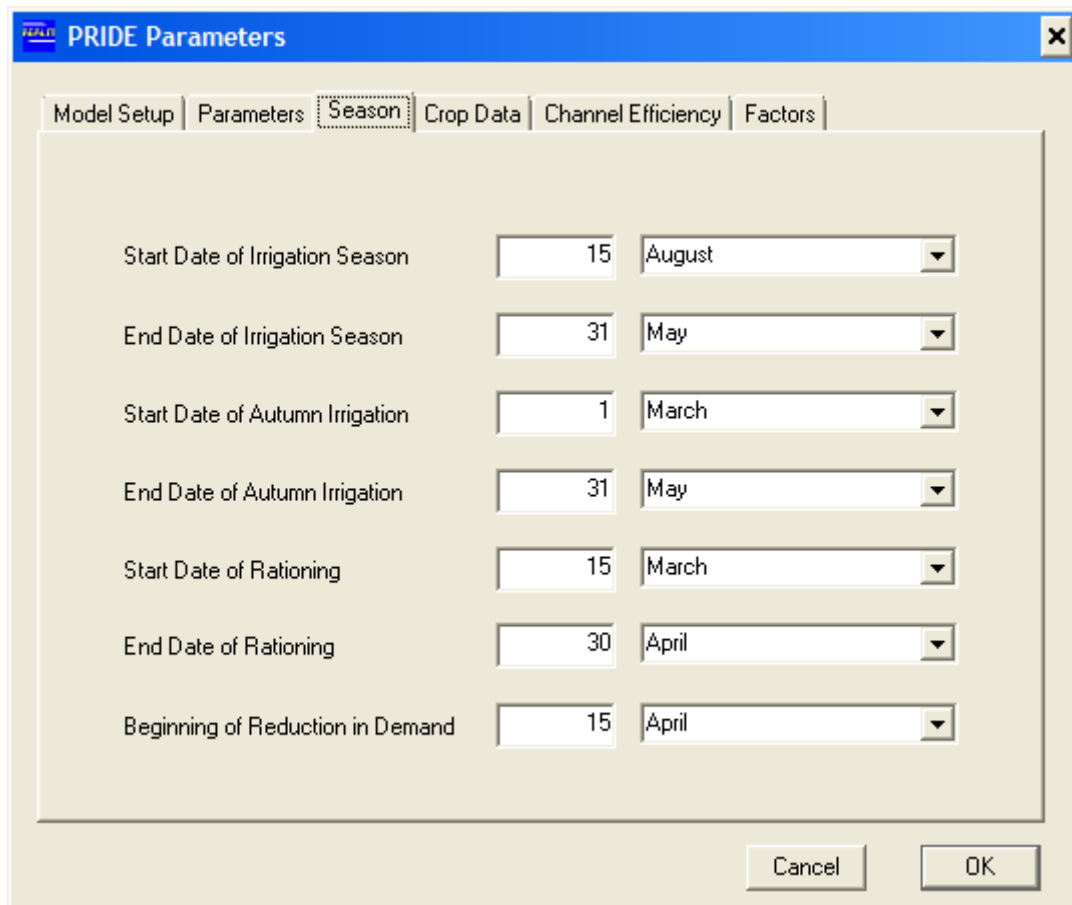


Figure 5-18 Parameters Tab of PRIDE Model Parameters Dialog Box

Parameters

Under the “Parameters” tab (Figure 5-18) the user can enter model parameters such as the Soil Drainage Factor. Refer to Section 5.2.2 of the PRIDE User Manual for further information on the meaning of these parameters.



The screenshot shows the "PRIDE Parameters" dialog box with the "Season" tab selected. The dialog box has a blue title bar and a close button (X) in the top right corner. Below the title bar are five tabs: "Model Setup", "Parameters", "Season", "Crop Data", and "Factors". The "Season" tab is active and contains seven rows of date selection fields. Each row consists of a text label, a numeric input field for the day, and a dropdown menu for the month. The fields are: "Start Date of Irrigation Season" (15, August), "End Date of Irrigation Season" (31, May), "Start Date of Autumn Irrigation" (1, March), "End Date of Autumn Irrigation" (31, May), "Start Date of Rationing" (15, March), "End Date of Rationing" (30, April), and "Beginning of Reduction in Demand" (15, April). At the bottom right of the dialog box are "Cancel" and "OK" buttons.

Field Name	Day	Month
Start Date of Irrigation Season	15	August
End Date of Irrigation Season	31	May
Start Date of Autumn Irrigation	1	March
End Date of Autumn Irrigation	31	May
Start Date of Rationing	15	March
End Date of Rationing	30	April
Beginning of Reduction in Demand	15	April

Figure 5-19 Season Tab of PRIDE Model Parameters Dialog Box

Season

Under the "Season" tab (Figure 5-19) the user has the ability to define the dates at which the irrigation season starts and ends, as well as other dates, such as the start of demand rationing. Note that for PRIDE version W1.1 the "End Date of Autumn Irrigation" is fixed at May 31st and cannot be changed by the user. Refer to Section 5.2.2 of the PRIDE User Manual for further explanation of these dates.

PRIDE Parameters

Model Setup | Parameters | Season | **Crop Data** | Channel Efficiency | Factors

Number of Crop Types: 6

Use Crop Area Data Timeseries?

	Crop Type	Crop Area	Crop Area Timeseries	Threshold
1	ANNUAL PASTURE	163.00		38.000
2	PERENNIAL	2274.0		38.000
3	LUCERNE	225.00		40.000
4	SUMMER CROP	30.000		60.000
5	WINTER CROP	142.00		60.000
6	ORCHARD	41.000		38.000

Cancel OK

Figure 5-20 Crop Data Tab of PRIDE Model Parameters Dialog Box

Crop Data

Under the “Crop Data” tab (Figure 5-20) the user can define the number, type and area of crops to be included in the model.

The number of crop types should be specified in the ‘Number of Crop Types’ field, which then automatically changes the number of rows in the table below. Each crop should be specified with a name in the ‘Crop Type’ field. This name must match a column name in the crop model input data files that contains the appropriate crop factors for that crop.

As per the standalone version of PRIDE, the user can enter crop area as a single value fixed for the period of the run or as a timeseries. Static crop areas can be entered in the ‘Crop Area’ field. To enable the use of a timeseries, select the ‘Use Crop Area Timeseries’ check box, and then enter a name in the ‘Crop Area Timeseries’ field that matches a column name in the crop model input data files.

In PRIDE version w1.1, the first crop type must always be “ANNUAL PASTURE”. Thus, there must be a column in the crop model input data files with the same name, even if there is no relevant data in this column. If the user does not wish to model annual pasture, the crop area should be set to zero. In PRIDE version w2.0, annual pasture can be any number crop in the data table, however the model will run a special autumn watering sub-routine for any crop type with the explicit name “ANNUAL PASTURE”. Refer to the PRIDE User Manual Section 3.5 for further information on the autumn watering sub-routine.

The crop threshold should be entered in the *'Threshold'* field.

For further information about the meaning and use of these variables, refer Sections 5.2.3 and 5.2.4 of the PRIDE User Manual.

PRIDE Parameters

Model Setup | Parameters | Season | Crop Data | Channel Efficiency | Factors

Number of Channel Efficiency Ordinates: 10

Channel Capacity: 99999

	Flow	Efficiency
1	0.0000	1.0000
2	700.00	1.0000
3	2000.0	1.0000
4	3000.0	1.0000
5	4000.0	1.0000
6	5000.0	1.0000
7	6000.0	1.0000
8	7000.0	1.0000
9	8000.0	1.0000
10	20000.0	1.0000

Cancel OK

Figure 5-21 Channel Efficiency Tab of PRIDE Model Parameters Dialog Box

Channel Efficiency

Under the “Channel Efficiency” tab (Figure 5-21) the user can define the efficiency of the irrigation supply system. As this is typically modelled using REALM itself, it is unlikely that this option will need to be used for a simulation where PRIDE demands are calculated within REALM, however it has been included for completeness, as it is an existing option in PRIDE. Refer Section 5.2.5 of the PRIDE User Manual for further information on these parameters.

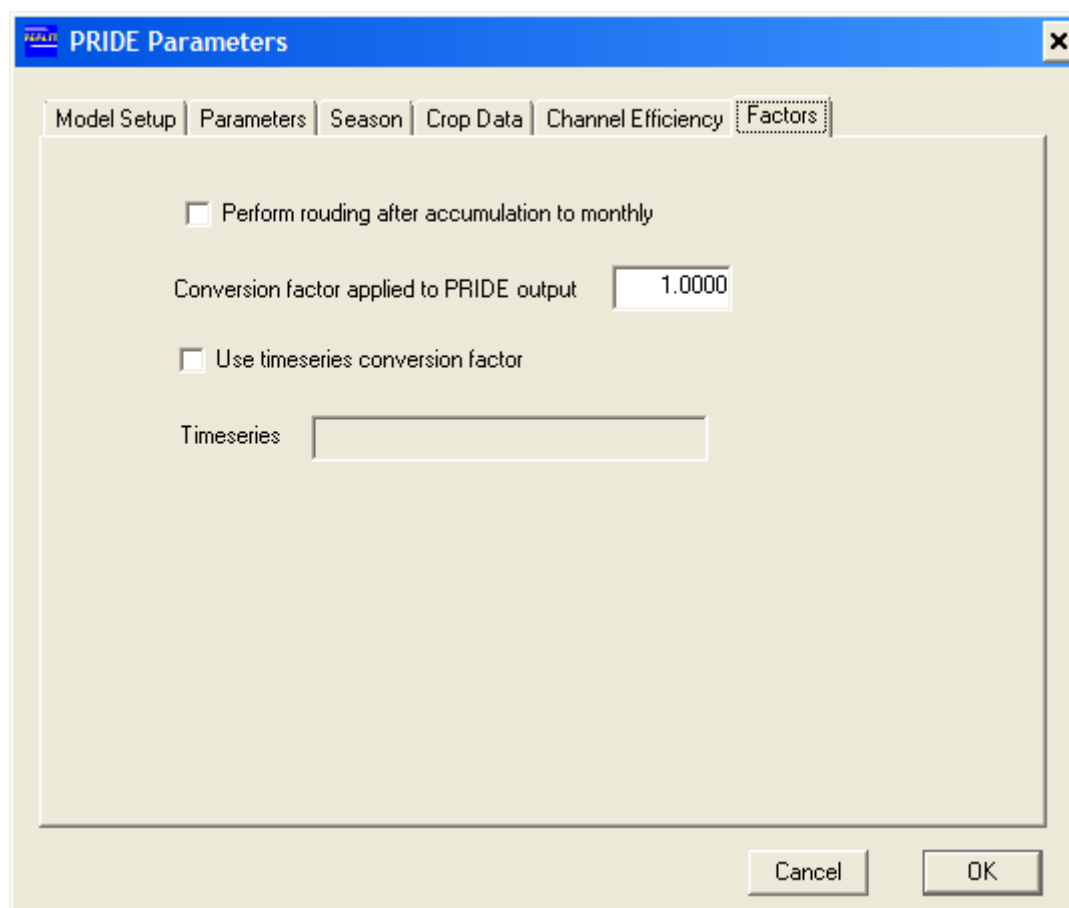


Figure 5-22 Factors Tab of PRIDE Model Parameters Dialog Box

Factors

Under the “Factors” tab (Figure 5-22) the user can enter various factors which can be used to modify the PRIDE model results. These factors are not available in the standalone version of PRIDE, but have been added to REALM to allow for the typical sorts of post-processing previously undertaken on demand timeseries produced using the standalone version of PRIDE.

If the user is running a monthly REALM model, tick the ‘*Perform rounding after accumulation to monthly*’ check box to ensure that REALM does not round the daily unrestricted demand values produced from PRIDE before aggregating them to monthly. If this box is not ticked, the reverse occurs, i.e. REALM rounds off the daily unrestricted demand values to two decimal places before aggregating them to monthly. This check box was added in order to be able to exactly replicate results from standalone PRIDE models. It will only change results for monthly REALM models, and the difference in model results whether the box is ticked or not will be minimal (typically in the order of 1 ML per month).

To apply a constant factor to the PRIDE results, enter the factor in the ‘*Conversion factor applied to PRIDE output*’ field. This factor is applied after the PRIDE results are rounded to decimal places.

Additionally, a timeseries factor can be applied to the PRIDE output by ticking the ‘*Use timeseries conversion factor*’ check box. The name of the timeseries corresponding to the name of a column in the crop model data input files should then be specified in

the 'Timeseries' field.

PRIDE Version 1.0 (DOS)

The DOS version of PRIDE is significantly different to the Windows version, both in terms of algorithm and input data. Because this version has been superseded for several years, it should only be used in cases where it is necessary to replicate within REALM data produced using the DOS version of PRIDE.

The DOS version of PRIDE runs on a seven-day week time step. Results are accumulated to monthly by factoring the weeks that overlap the start or end of a month by the proportion of days within the month. The model is hard-coded to define the start of the irrigation 'year' (and therefore the first time step) as July 1st. The second time step starts on July 8th, and so on. In a normal year, this leaves one day left over (two days in a leap year) at the end of the year, June 30th. No calculations are undertaken for this day as it assumed that this period is so far outside the irrigation season that there will be no demands.

Because of these limitations, the DOS version of PRIDE in REALM can only be used for monthly models. REALM will not permit system files containing DOS PRIDE models to be run at a weekly or daily time step. It is also strongly recommended that REALM models containing DOS PRIDE models be set up so that the first time step of the run is July and the last time step is June.

The input data for the DOS version of PRIDE is entered in similar dialog boxes as for versions w2.0 and w1.1. There are a few differences, which are noted below.

- Under the "Model Setup" tab, the user must enter one evaporation timeseries and two rainfall timeseries. A factor of 0.5 is automatically applied to each rainfall timeseries. If the user only wants to use a single timeseries, the same column name should be entered in both fields.
- Under the "Parameters" tab, the user must define the distribution of annual pasture in each sub-area. This distribution is assumed to be uniform in version w2.0 and w1.1 of PRIDE, but can be specified in the DOS version. Note that the distributions are entered as percentages and must sum to 100.
- Under the "Season" tab, the start and end dates of the irrigation season and other key dates must be entered as week numbers. As an example, the week starting July 1st is week 1, and the week starting July 8th is week 2. In a normal year, the week starting June 23rd (June 22nd in a leap year) is week 52.
- As for PRIDE version w1.1, the first crop type specified in the "Crop Data" tab is considered to be annual pasture and is subject to an additional autumn watering subroutine.
- Under the "Factors" tab the 'Perform rounding after accumulation to monthly' check box is not available because the rounding is automatically done prior to accumulation. This emulates how the standalone version of DOS PRIDE works.

Crop Model Data Files

Refer to Section 6.4.3.

5.5.2.4 MODELLING CARRYOVER IN REALM

The carryover function enables the user to configure rural demand nodes (DC2) such that unused water allocations are held in storage and carried over for use the following year. The capacity to model carryover in REALM has been developed to inform water policy in Victoria. As a result, the terms used to define the carryover function may be unfamiliar to many REALM users. Key terms are defined below.¹

The carryover algorithm in REALM has two main steps:

1. REALM calculates the volume of water carried over at each rural demand node (DC2) at each time step;
2. REALM adjusts the limit curve at each demand node depending on the accessible volume of water carried over from the previous season and the volume of water planned to be carried over to next time step.

The carryover algorithm is described in the Modelling Carryover in REALM: File Note, which may be downloaded by following the instructions under Section 1.5.3.

Carryover types

Carrying over unused water in storage from the previous year reduces the storage space available to harvest water for the current year's allocations. The aim of two carryover methods developed is to prevent carryover having an adverse impact on allocations. These methods available in REALM are:

Capped volume of carryover:

This method prevents individuals using more storage capacity than they are entitled to by limiting the volume of water available to an entitlement holder in any one year. For example, an entitlement holder's carryover from last year plus allocations from the current year could be capped at 100% of the volume of entitlement.

Spillable water accounts:

This method allows individuals to use more storage capacity than they are entitled to when there is spare capacity available. This means that carryover water is only lost if the dams actually spill. The volume of water that may be lost if dams spill is tracked in spillable water accounts.

Carryover terminology

Carryover is an arrangement that allows entitlement holders (e.g. irrigators) to retain all or some part of any given year's water allocation in storage. This water is then available for use in the following year, subject to management rules (e.g. losses).

Desired Carryover is the water that irrigators (as represented by a rural demand node) plan to carryover. It is expressed as a percentage of effective allocation.

Effective Allocation is the volume of water available to entitlement holders in any time step. It is the total of the water from current season's allocation less volume planned

¹ Definitions adapted from: (1) "Carryover: Your guide to understanding carryover for the Murray, Goulburn, Campaspe, Loddon, Broken and Bullarook regulated systems 2012/13". This brochure may be downloaded from Goulburn-Murray Water's webpage.

to be carried over to next time step, plus any accessible volume of unused water carried over from last year.

High reliability (water share) is an entitlement against which water allocations are made as a first priority.

Low reliability (water share) is an entitlement to a share of the water in a declared water system. It is called low-reliability because the allocation is less likely to reach 100% than for high-reliability water shares because high-reliability water shares have a higher priority.

Spillable water account keeps track of casual access to storage space for carryover water that may be lost if the dams spill. Spillable water accounts allow individuals to utilise more storage capacity than they are entitled to, provided that there is spare capacity available.

Spillable water is additional water above full entitlement volume in systems with spillable water accounts. Not all carryover is at risk of being lost if storages spill. Each entitlement holder is allowed to hold in storage – from carryover and/or new allocation – a volume equivalent to 100% of their entitlement volume. This water is not at risk of spill. When a spillable water account operates, the entitlement holder can continue to receive further allocation increases. Any water above the 100% entitlement volume is kept aside as spillable water, and is at risk of being lost if a storage spill is triggered.

Spill trigger specifies whether the water stored in spillable water accounts is available to entitlement holders for use or not. The water stored in the spillable water accounts is not available for use until there is an acceptable risk of the storage not spilling for the rest of the water year. In REALM, the user needs to define the spill trigger in a variable capacity carrier.

To enter carryover parameters:

Note: to ensure that all functionality within the carryover window is active, it is strongly recommended that the limit curve be defined for the rural demand centre before carryover parameters are entered (see Section 5.5.2.2)

Select the “Carryover” tab in the “Edit Rural Demand Centre” dialog box (Figure 5-12).

Select the check box ‘*Allow this demand centre to carryover unused allocation to next season*’ (Figure 5-23).

Enter the percentage allocations into the ‘*Allocation at Entitlement*’ fields to specify the point on the limit curve defining high and low reliability water shares.

If the limit curve has been completed (in the “Limit Curve Based Restrictions” tab), REALM will automatically calculate the volume of water at each allocation in the ‘*Entitlement*’ fields. These fields cannot be edited by the user – they are intended as a check to ensure that the correct allocations have been entered.

Note: it is strongly recommended that the limit curve be defined for the rural demand centre before carryover parameters are entered.

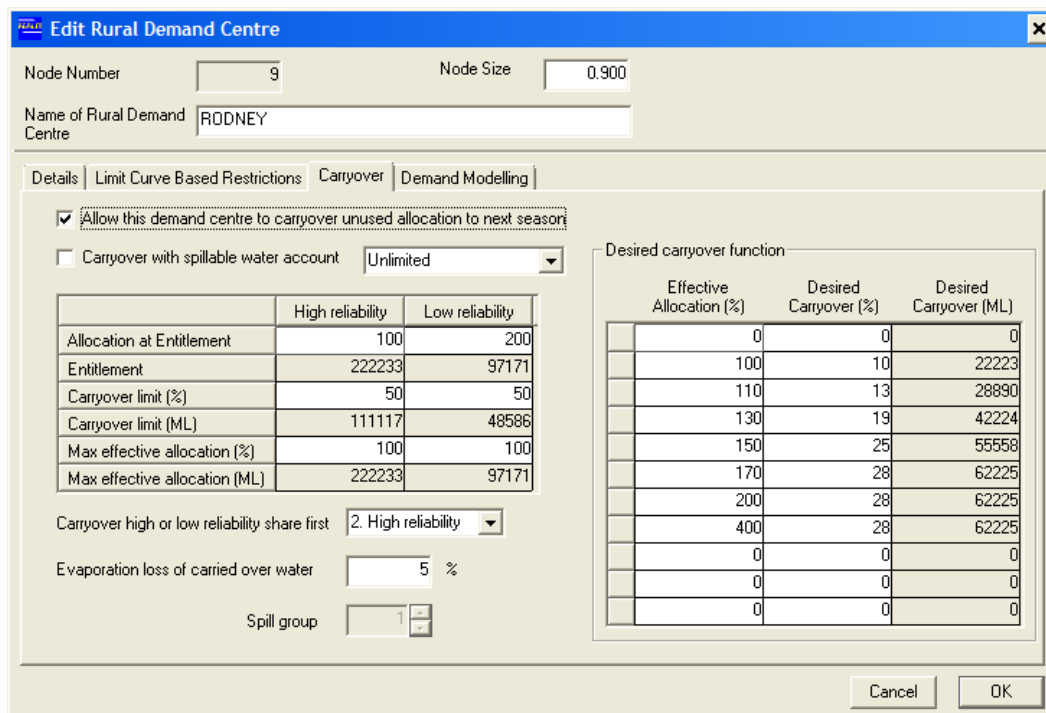


Figure 5-23 Carryover Tab in Edit Rural Demand Centre Dialog Box

REALM enables two types of carryover limit to be modelled

1. **Capped volume of carryover (no spillable water account):** The user specifies a limit on the maximum volume of carryover. If the sum of last year’s carryover plus this year’s allocation exceeds the limit, the excess carryover is forfeit. This forfeit water returns to the common “pool” for allocation.
2. **Carryover with spillable water account:** Under this option, REALM automatically places an upper limit on the total volume of water (i.e. carryover plus current year’s allocation) that may be held in storage without risk of loss to spills. This limit is equivalent to 100% of entitlement. Any allocation in excess of 100% of entitlement is transferred to the spillable water account. This excess carryover may be partially or wholly spilt if a trigger is reached.

The volume that may be transferred to the spillable water account is either:

- a. **Limited** to a percentage of entitlement – there is an upper limit (typically 100% of entitlement) on how much water may be carried over at the end of each water year.
- b. **Unlimited** – the volume that may accrue in the spillable water account is limited only by the available of space to store the water.

The parameters to be entered differ depending upon: (i) whether or not a spillable water account is modelled and, when a spillable water account is modeled, (ii) whether or not the volume that may accrue in the spillable water account is limited or unlimited.

The following parameters become inactive when the *'Carryover with spillable water account'* check box is selected, and *'Limited'* is displayed in the drop down box:

- Maximum effective allocation
- Order of carryover.

When the *'Carryover with spillable water account'* check box is selected, and *'Unlimited'* is displayed in the drop down box, the following additional parameter becomes inactive:

- Carryover limit.

Carryover limit

These limits are to specify the maximum amount of water that can be carried over. Enter percentages for high and low reliability entitlement in the *'Carryover limit (%)'* field. The equivalent volume is automatically calculated from the limit curve and placed in the *'Carryover limit (ML)'* field.

Maximum effective allocation

The maximum effective allocation is the highest allocation that can be provided in the season following a carryover. This is specified in the *'Max effective allocation (%)'* field. The equivalent volume is automatically calculated from the limit curve and placed in the *'Max effective allocation (ML)'* field.

Order of carryover

Specify whether the volume of water is to be carried over as the high or low reliability water share first by changing the option selected in the *'Carryover high or low reliability share first'* drop down box.

Loss to evaporation

Specify the percentage of the carried over water lost to evaporation in the *'Evaporation loss of carried over water'* field.

Enabling spillable water accounts

Select the check box *'Carryover with spillable water account'* to model carryover with spillable water accounts.

Spill group

Selecting the check box *'Carryover with spillable water accounts'* activates the *'Spill group'* field. Enter a spill group for this demand node. Each spill group also requires that variable capacity carriers be defined, which control the spill trigger and spill volume for that group. These carriers are specified in the "Spill groups" dialog box which is accessed by selecting the *Edit::Spill groups* menu item **or**

Clicking on the  *'Edit spill groups'* button in the System Editor window (Figure 5-1).

Desired carryover function

The user must also define the "Desired carryover function". The "Desired carryover function" indicates how much water irrigators will choose to carryover depending on the effective allocation at a particular time step in the season. Similar to the limit

curve, the user should enter percentage effective allocation values into the 'Effective Allocation (%)' field, and percentage carryover values into the 'Desired Carryover (%)' field. REALM automatically calculates a volume for each allocation in the 'Desired Carryover (ML)' field by referencing the limit curve.

The "Desired carryover function" should be derived from observed or theoretical irrigator behaviour. An example carryover function is shown in Figure 5-24, from which it can be seen that 5% of the allocation is carried over for effective allocations between 10% and 60%. At low allocations, the irrigator is likely to carryover some water to provide a potential supply in case of even lower allocations next year. As the allocation rises, the irrigator is likely to commit a greater percentage to carryover and thus create additional flexibility for the following season.

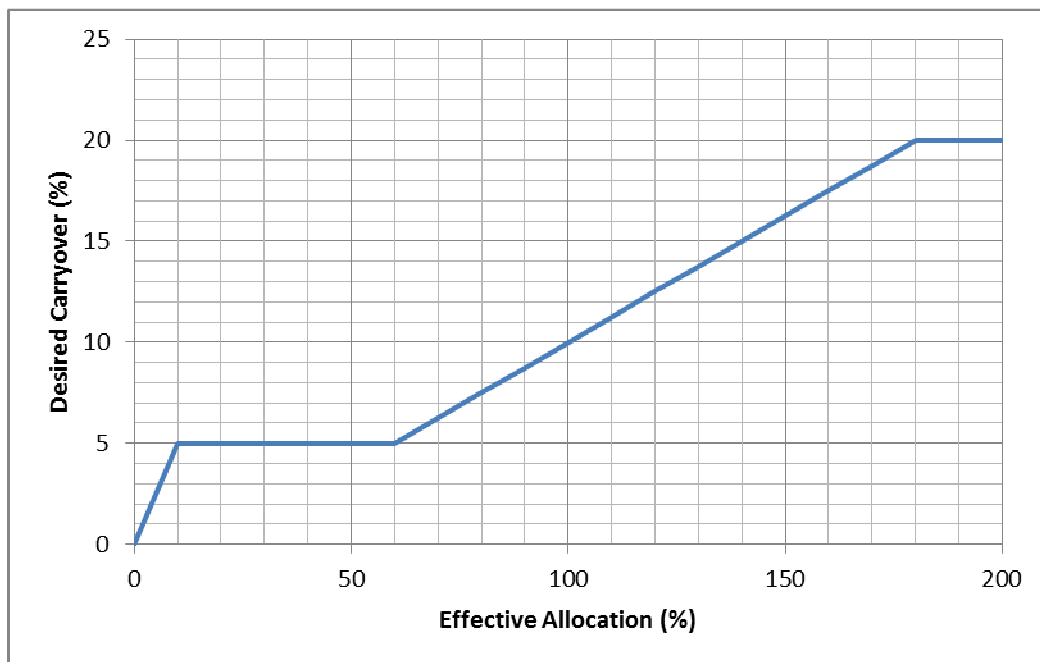


Figure 5-24 Example Desired Carryover Function

Carryover Output

A number of additional system variables were introduced with carryover to allow various carryover parameters to be referenced in carrier equations and thus used in different parts of the model. These are shown in Table 5-1. To examine outputs, the user need to include variable capacity carriers and reference to relevant output type in the carrier capacities (refer to Section 5.6.4.4).

Table 5-1 Available Carryover System Variables for Variable Capacity Carrier Modelling

Variable Name	Sub-group	Type	Type Description	Variable Name and Type	Remarks
Node name	Rural demand (DC2)	DCVR	Desired carryover (ML)	RODNEY and LALL	RODNEY is a rural demand node (DC2) name in the system file
		ATCV	Total actual carryover (ML)		
		CVRH	Actual high reliability share carryover (ML)		
		CVRL	Actual low reliability share carryover (ML)		
		LALL	Adjusted low reliability share limit (ML)		
		HALL	Adjusted high reliability share limit (ML)		
		CEVP	Volume of carried over water lost to evaporation (ML)		
		VSWA	Total volume transferred into spillable water account (ML)		
		AVSW	Adjusted spillable water account (ML)		
		SWAL	Available allocation (ML)		
		ADJL	Adjusted limit (ML)		
		ALML	Effective allocation (ML)		
		ALVL	Effective allocation (%)		

5.5.3 PIPE JUNCTION NODE (PJ)

The pipe junction node (PJ) represents a junction of pipe carriers where no natural streamflow can enter the water supply system at this junction. It can be a junction of several inflow and outflow pipes, or one inflow and one outflow pipe with different capacities. Figure 5-25 is displayed when the PJ node is created or edited, allowing the user to enter or edit the following information. As in other nodes, the only difference between the editing and creating pipe junctions node dialog box is the header.

5.5.3.1 BASIC PROPERTIES

Three basic properties define the pipe junction node as unique identifiable object in the system, as described below.

Node Number

This is an auto-generated number to identify the node in the system file. The user has no control over this field.

Node Size

Node size gives a perspective view to the system. Node size can be represented by a real positive number between 0.1 and 10.0. Large numbers display the node as a large node in the network screen and vice versa. This information does not have an impact on the simulation.

Name of Pipe Junction

The pipe junction name should be entered in this field. It is advisable to use meaningful names for each node. This name is used in collating the output. The error message *'Duplicate node name (1st 15 chars)'* is displayed on the screen if a node name that has been previously used is entered.

5.5.3.2 PIPE JUNCTION NODE DETAILS

The "Details" tab for the pipe junction node contains only one field *'Description'*.

Description

An optional comment can be entered in this field to describe the pipe junction. This information does not have an impact on the simulation.

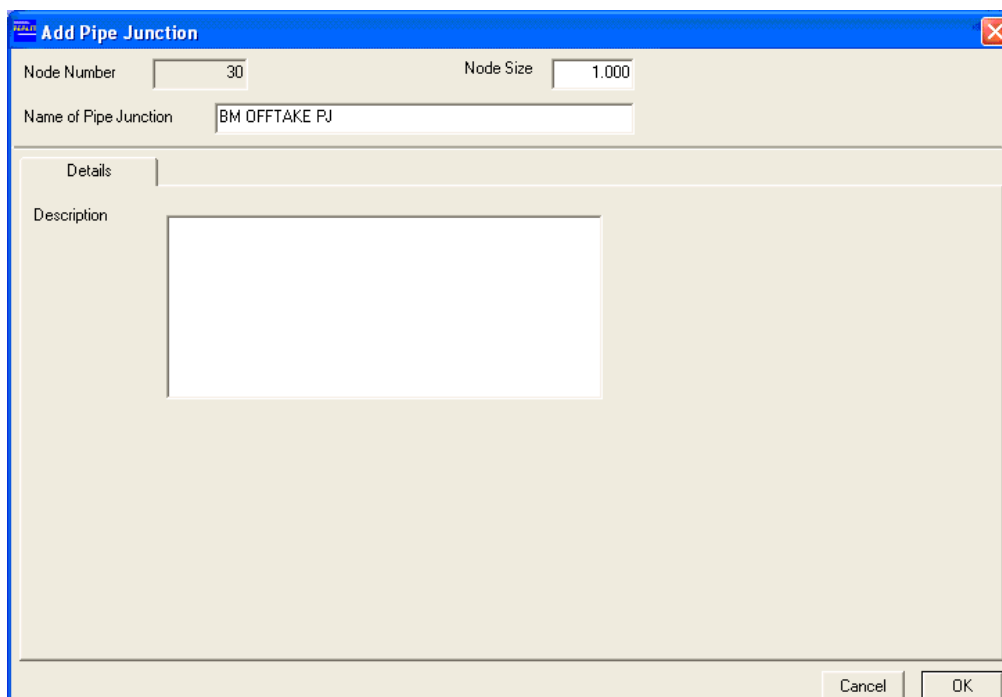


Figure 5-25 Adding/Editing Pipe Junction Node Dialog Box

5.5.4 STREAM JUNCTION NODE (SJ)

The stream junction node (SJ) represents a junction of rivers/streams. It may receive natural streamflows. It can be a junction of several inflow and outflow rivers/streams, or one inflow and one outflow river/stream with different capacities.

When the SJ node is created or edited, the dialog box shown in Figure 5-26 is displayed. As in other nodes, the only difference between the editing and creating stream junction node dialog box is the header. The user is required to enter the node information as described below.

5.5.4.1 BASIC PROPERTIES

The information required for the fields 'Node Number', 'Node size', and 'Name of Stream Junction' is analogous to that for the pipe junction (PJ) node (Section 5.5.3).

Figure 5-26 Adding/Editing Stream Junction Node Dialog Box

5.5.4.2 STREAM JUNCTION NODE DETAILS

The basic details of the stream junction node can be entered in the "Details" tab under fields mentioned below.

Description

An optional comment can be entered in this field to describe the stream junction. This information does not have an impact on the simulation.

External Data Record Name

The stream junction may or may not receive local inflow from its catchments. If it receives local inflow, then tick the check box 'Use Inflow Data'. This allows the user to

enter the *'External Data Record Name'*, which **should** be a name of streamflow data column in a streamflow file used in the REALM application. It **should** be correctly spelled (including the case) as the column name given in the streamflow file. The streamflow column should contain time series data of streamflow at this stream junction. If the stream junction does not receive local inflow, the check box *'Use Inflow Data'* should not be ticked.

The external input data should contain only the incremental (or lateral) inflow between this node and the previous upstream node that receives inflow, to avoid double counting.

5.5.4.3 STREAM JUNCTION WATER QUALITY PARAMETERS

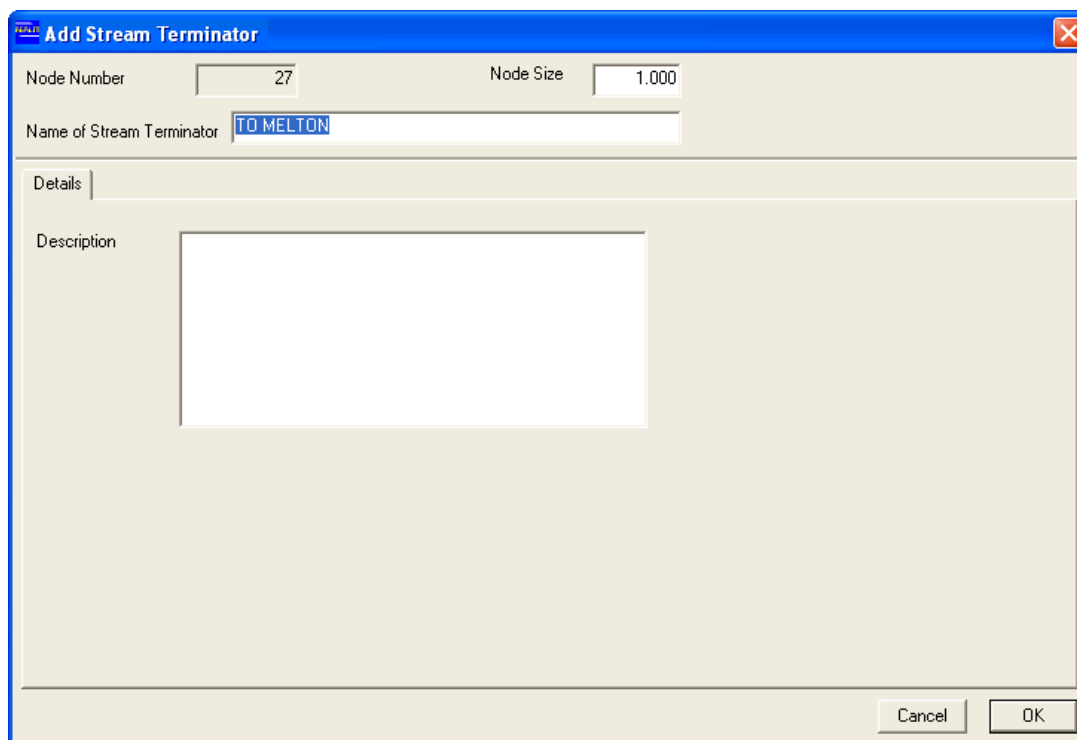
Water quality parameters can be modelled by selecting the "Water Quality" tab option. This tab is exactly same as Figure 5-10, except for the node name. The details are explained in Section 5.4.4.5.

5.5.5 STREAM TERMINATOR NODE (ST)

The stream terminator node (ST) represents the last point of each river/stream system. This node ensures that only flows that cannot be regulated leave the water supply system.

5.5.5.1 BASIC PROPERTIES/DETAILS

The dialog box shown in Figure 5-27 is displayed when the ST node is created/ edited. The information required for the fields *'Node Number'*, *'Node size'*, *'Name of Stream Terminator'*, and *'Description'* is analogous to that for other node types, such as the pipe junction (PJ) node (Section 5.5.3).



The screenshot shows a Windows-style dialog box titled "Add Stream Terminator". It features a blue title bar with a close button (X) in the top right corner. The main area is light beige and contains the following elements:

- Node Number:** A text box containing the number "27".
- Node Size:** A text box containing the value "1.000".
- Name of Stream Terminator:** A text box containing the text "TO MELTON".
- Details:** A tabbed section with a "Details" tab selected. Inside this section is a "Description" label followed by a large, empty rectangular text area for entering a description.
- Buttons:** "Cancel" and "OK" buttons are located at the bottom right of the dialog.

Figure 5-27 Adding/Editing Stream Terminator Node Dialog Box

5.6 CARRIERS

REALM allocates water within the water supply system (i.e. from supply points to demand zones) through a network of carriers. Each carrier in the network has a maximum capacity, which represents an upper limit for water flow. This water flow may be less than the maximum capacity as a result of the implementation of the operating rules for that simulation time step.

5.6.1 CREATING/EDITING CARRIERS

Two different types of carriers are available in REALM:

1. River type carriers represent river sections;
2. Pipe type carriers represent pipes, aqueducts and general carriers which are not river sections.

Carriers are represented by items in the *Add* menu, as well as by the following buttons on the toolbar:



River carrier



Pipe carrier.

To create a carrier:

Click on the appropriate carrier button on the toolbar **or**

Select the appropriate carrier type from the *Add* menu.

The mouse pointer will change colour from white to blue (river carrier) or grey (pipe carrier).

Click on the node where the carrier starts and drag the mouse to the node where the carrier ends and click on this node. This will create the carrier. (Drawn as a single line between two nodes with an arrow head in the middle.)

Enter the relevant parameters in the “Add carrier” dialog box that appears.

Click on the **OK** button to make this carrier visible in the workspace.

The user may wish to create a carrier with an offset so that two or more carriers from the same two nodes will not overlap. This can be done by clicking on the node where the carrier starts, then dragging the mouse to a point away from the straight line between the two nodes and clicking on this point, and finally dragging the mouse to the node where the carrier ends and clicking on this node.

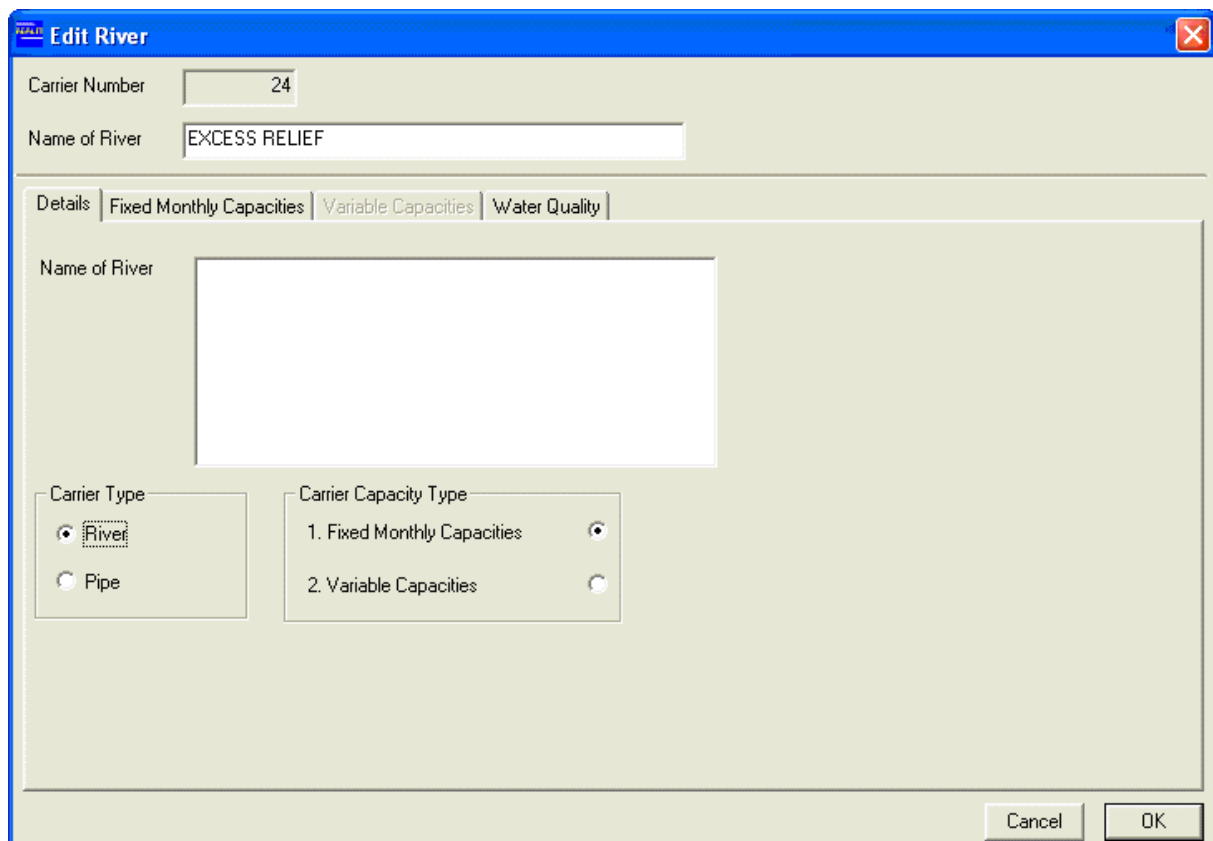


Figure 5-28 Adding/Editing River Carrier Dialog Box

To edit a carrier:

Click on the  'Select and edit a node or a carrier' button.



Double click on the arrow head of the carrier to be edited.

Edit the relevant parameter in the "Edit carrier" dialog box.

The details required to model river carriers and pipe carriers are exactly the same, and they are explained together in Section 5.6.4.1 to Section 5.6.4.7.

5.6.2 MOVING CARRIERS


To change the offset:


Click on the  'Select and move a node or a carrier' button. The mouse pointer will be changed to the  hand.

Click on the arrow head of the carrier and, holding down the left mouse button, drag the carrier to the desired position.

To reposition a carrier into other nodes:



Either end of a carrier can be re-assigned to another node.

Click on  'Change the destination node of a carrier' if the destination node attached to the carrier is to be changed **or**

Click on  'Change a node from which a carrier originates' if the node from which a carrier originates is to be changed.


Click on the arrow head of the carrier to be moved. The carrier will be highlighted to indicate that it is ready to be moved.

Click on the new destination/origin node for the carrier. One end of the carrier will move accordingly.


If both ends of the carrier are to be changed, then follow the above process first with the  'Change the destination node of a carrier' button and then with the  'Change a node from which a carrier originates' button.

5.6.3 DELETING/UNDELETING CARRIERS

To delete a carrier:

Click on the  'Delete a node or carrier' button **or**

Select the menu item *Edit::Delete node/carrier*.


The mouse pointer will turn into an eraser .

Position the left edge of the mouse pointer over the carrier to be deleted and click.

A popup message box will appear to confirm the deletion.

Click **Yes** to delete the carrier or **No** to return to the SE without deleting the carrier.

To undelete a carrier:

Click on the  'Undo all actions up to and including last delete action' button **or**

Select the menu item *Edit::Undo Delete*.

Note that when the user acquires a deleted carrier, all the changes made after deleting this particular carrier will also be reversed and removed.

5.6.4 RIVER CARRIERS AND PIPE CARRIERS

5.6.4.1 BASIC PROPERTIES

Basic properties define the carrier as a uniquely identifiable object in the system.

Carrier Number

This is an auto-generated number to identify the carrier in the system file. The user has no control over this field.

Name of River/Pipe

The carrier name should be entered in this field. It is advisable to use a meaningful name for the carrier. This name is used in collating the output. An error message 'Duplicate carrier name (1st 15 chars)' is displayed on the screen if a carrier name that has been previously used is entered.

5.6.4.2 DETAILS

Description of River/Pipe

An optional comment can be entered in this field to describe the carrier. This information does not have an impact on the simulation.

Carrier Type

In Figure 5-28, the carrier type is already selected as the River type. However, the opportunity exists to change the type of this carrier from River to Pipe or vice-versa using the appropriate radio button. Note that if the user changes the 'Carrier Type' from 'River' to 'Pipe' in Figure 5-28, then the label 'Name of River' will change to 'Name of Pipe'.

Carrier Capacity Type

The user can select the "Carrier Capacity Type" using the appropriate radio button – either 'Fixed Monthly Capacities' or 'Variable Capacities'. This selection will change the colour of the relevant tabs. For example, if the 'Variable Capacities' radio button is selected, the "Fixed Monthly Capacities" tab is greyed out and the "Variable Capacities" tab becomes active (Figure 5-28).

The default carrier capacity is 'Fixed Monthly Capacities', which means that the carrier's maximum capacity is defined by fixed monthly values.

When 'Variable Capacities' is selected, the maximum capacity of the (variable capacity) carrier depends upon one or more system variables, and is computed during each time step of the simulation based on the values of these system variables.

The maximum capacity can be used to simulate the real (physical) capacity of the carriers, as well as operational considerations. The most common carrier type has a physical maximum capacity that is the same for all months in the year. This situation is modelled as 'Fixed Monthly Capacities'. In other cases, it is necessary to have different maximum but fixed flows in different months, due to operational considerations. Again, this situation is modelled with 'Fixed Monthly Capacities'.

'Variable Capacities' is used to model a situation where the maximum capacity of a carrier is not fixed, but instead depends upon one or more system variables, due to operational considerations. One example of a variable capacity carrier would be a carrier representing hydropower releases, which depend on the hydraulic head of the reservoir above the outlet. These variable capacity carriers can be turned off, if required.

5.6.4.3 FIXED MONTHLY CAPACITY CARRIERS

Click on the "Fixed Monthly Capacities" tab to enter the details of fixed capacity carriers. This will display a dialog box (Figure 5-29), which allows the user to enter the required details.

Carrier Number: 193

Name of Pipe: TO F5 FARMDAMS

Details | Fixed Monthly Capacities | Variable Capacities | Water Quality

Penalty: -55000000

Loss*: 0

*Note losses denoted by a positive number represent a % loss, while those denoted by a negative number represent a fixed or constant loss

Capacity Sharing Group

Group ID: 0

% Share*: 0.00

*Note % share denoted by a positive number represents a whole number share, while those denoted by a negative number represents a share with two decimal places

	Minimum Flows	Maximum Capacity
January	0	99999999
February	0	99999999
March	0	99999999
April	0	99999999
May	0	99999999
June	0	99999999
July	0	99999999
August	0	99999999
September	0	99999999
October	0	99999999
November	0	99999999
December	0	99999999

Cancel OK

Figure 5-29 Fixed Monthly Capacities Tab of Edit/Create Carrier Dialog Box

Penalty

The 'Penalty' (or cost) field is used to allocate water within the water supply system. These penalties are used in Network Linear Programming module in allocating water. If there is more than one carrier between two nodes, the lowest penalty carrier is used first. When the capacity constraint of this carrier is reached, the next lowest penalty carrier is used and so on until all demands are satisfied.

A high penalty tends to discourage the use of that carrier, while a negative cost will maximise the use. The default value is 0. If there are two carriers from one node, one supplying a demand zone and the other a transfer carrier, then the penalty of the former can be set at 0, while that of the latter can be set at 50, which essentially supplies the demand before any transfers from this node. The **relative** magnitudes of carrier penalties are important in allocating water in carriers, and not the absolute values of the penalties. In Figure 5-29, a very high negative penalty (i.e. -55,000,000) has been used to ensure that flows to farm dams in the catchment are always taken out of the water system before inflows from the catchment reach the reservoir.

Loss

The 'Loss*' field represents the transmission losses. The transmission losses of carriers can be specified as either a fixed quantity by entering a negative value or as a percentage of flow by entering a positive value in the 'Loss' field. For river reaches requiring both fixed and percentage losses, two carriers in series can be used, one with a fixed quantity and the other with a percentage of flow. The transmission losses include the evaporation losses, seepage losses and any other form of loss of water in the carriers.

The loss relationships require several iterations to reach the solution in the simulation when the carrier loss is modelled as a percentage of flow. A trial solution is found before the actual losses are determined. The simulation module then modifies the losses and re-solves the allocation. This process continues until convergence is reached. The convergence criteria are specified by the user by changing the corresponding values in *realm.set* file before setting up the simulation (i.e. use of REALM Setup S). This can be done using the “Convergence/Iteration” tab of *Run::Options*. The following convergence criteria are used in REALM in modelling the transmission losses:

1. percentage difference in losses between two consecutive iterations less than a certain tolerance;
2. a maximum number of iterations.

The solution is considered as converged when one of its criteria is satisfied. The option (2) is used only to stop endless looping. If this occurs, a warning message related to non-convergence at this simulation time step is given in the simulation log file.

REALM takes out the loss at the bottom end of the carriers. Therefore, the carrier flow output file and the log file contain flows corresponding to the upstream end (i.e. flow without losses taken out).

Capacity Sharing:

Capacity sharing refers to a situation where the maximum capacity of a physical carrier is shared by two or more water user groups. This is modelled in REALM by having a separate carrier for each user group, but representing the same physical carrier. However, these carriers should be assigned to a single group. The share of the capacity that each user group can access is also specified. If a user group does not use its share of the carrier capacity, the other user groups can use the unused capacity in proportion to their defined shares.

There are two capacity sharing fields (i.e. ‘*Group ID*’ and ‘*%Share**’) (Figure 5-29). The capacity sharing group field (‘*Group ID*’) allows the user to assign each of the carriers representing a capacity share in a single physical carrier to a group with a unique identification number. In the ‘*%Share**’ field enter the percentage of the carrier capacity that this particular carrier (representing a user group) can use. It can be specified as either an integer percentage by entering a positive value or a percentage with two decimal places by entering a negative value in the ‘*%Share**’ field.

For example, if the capacity of a carrier is to be shared by three user groups, then there should be 3 capacity-shared carriers, each representing the (same) physical carrier. The ‘*Group ID*’ field of each of these carriers should have the same identification number (i.e. same integer number), but one carrier with the negative sign preceding the number to indicate the key group member. The user has to enter the maximum capacity details only for the key member and this maximum capacity information is automatically considered in capacity sharing of the carriers of this group during run time. This maximum capacity can be modelled either with ‘*Fixed Monthly Capacities*’ or ‘*Variable Capacities*’.

The user is referred to the paper on “Modelling of Capacity Shared Water Entitlements” by Barry James, Kes Kesari and William Hansen for theoretical

considerations of carrier capacity sharing and modelling. This paper also discusses the concept of capacity shared systems in general.

Minimum and Maximum capacities:

The minimum capacities are used to specify the minimum flow requirements to maintain environmental or river freshening flows, while the maximum capacity of the carrier defines the maximum flow that is allowed in this carrier. These minimum and maximum capacities can vary with the month.

5.6.4.4 VARIABLE CAPACITY CARRIERS

Click on the “Variable Capacities” tab to enter the details of variable capacity carriers. This will display a dialog box (Figure 5-30), which enables the user to enter the required details. All details in this figure are same as the fixed capacity carriers (Section 5.6.4.3). Click on **Edit Capacity Relationship** to enter the specific details of the variable capacity carriers. This will show the “Edit Capacity Relationship” dialog box (Figure 5-31).

Equation

An equation to calculate the capacity of the carrier is entered in the ‘Equation=’ field. This equation defines a temporary variable, which is represented by ‘Independent Variable’ in the ‘Transformation Table’. Setting up of the equation is detailed in Section 5.6.4.5.

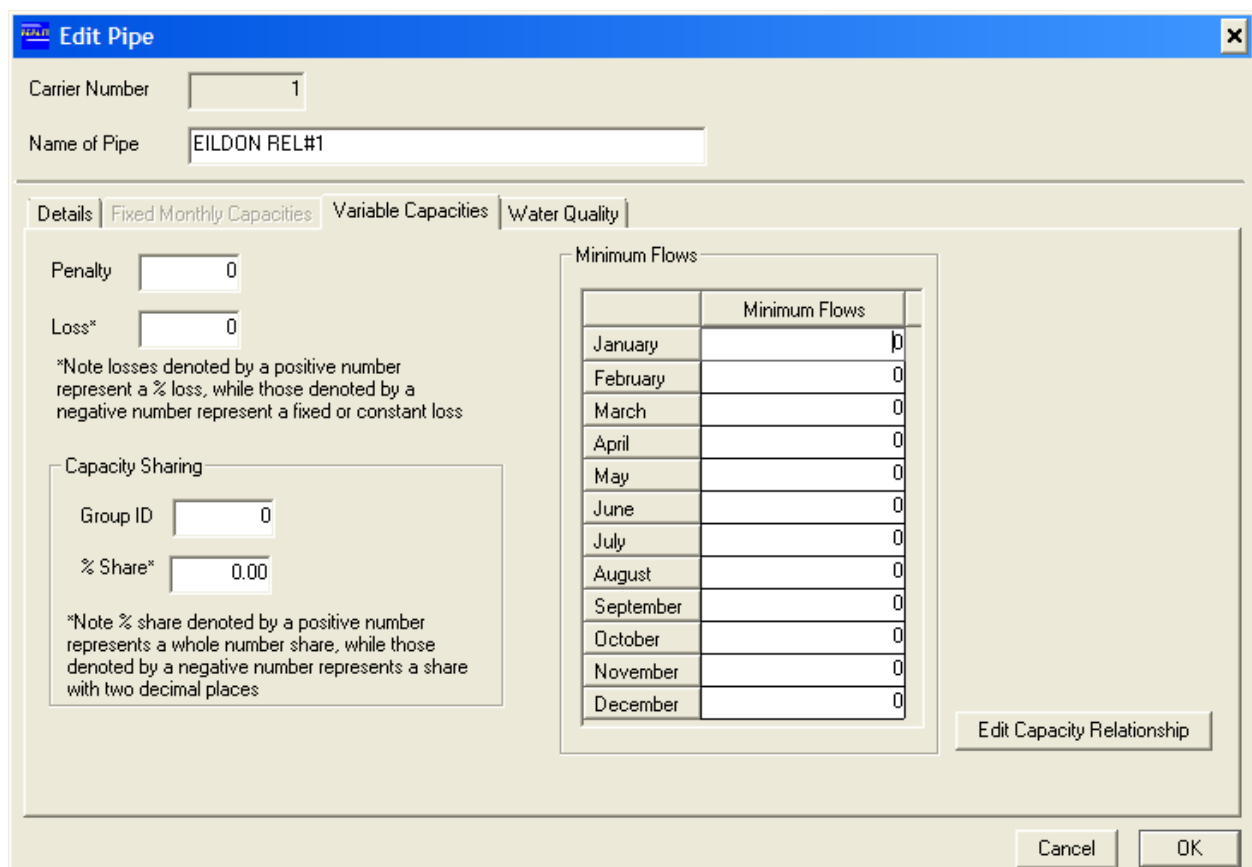


Figure 5-30 Variable Capacities Type Tab of Add/Edit Carrier Dialog Box

Variable Name and Type

System variables used in the equation and their types must be declared in the “Variables in Above Equation” block. ‘Variable Name’ has to be inserted. The ‘Type’ field can be populated by typing in the appropriate cell or by clicking on the **Type** button at the bottom of the table to display a drop down box, and then making a selection from the drop down box. The list of variable types in the drop down box and a description of each type are given in Table 5-2.

The system variable can be a name of reservoir node, a name of a demand node, a name of a carrier, a column name of a streamflow or a column name of demand file. These names **should** be exactly same (including the case) as in system, streamflow and demand files relevant to the application. In addition, two key words, TOTAL STORAGE and TOTAL DEMAND can also be used.

The variable name of the system variable(s) is matched in REALM during run time. The matching sequence is as follows:

- Keywords
- Node names
- Carrier names
- Column names streamflow files
- Column names of demand files

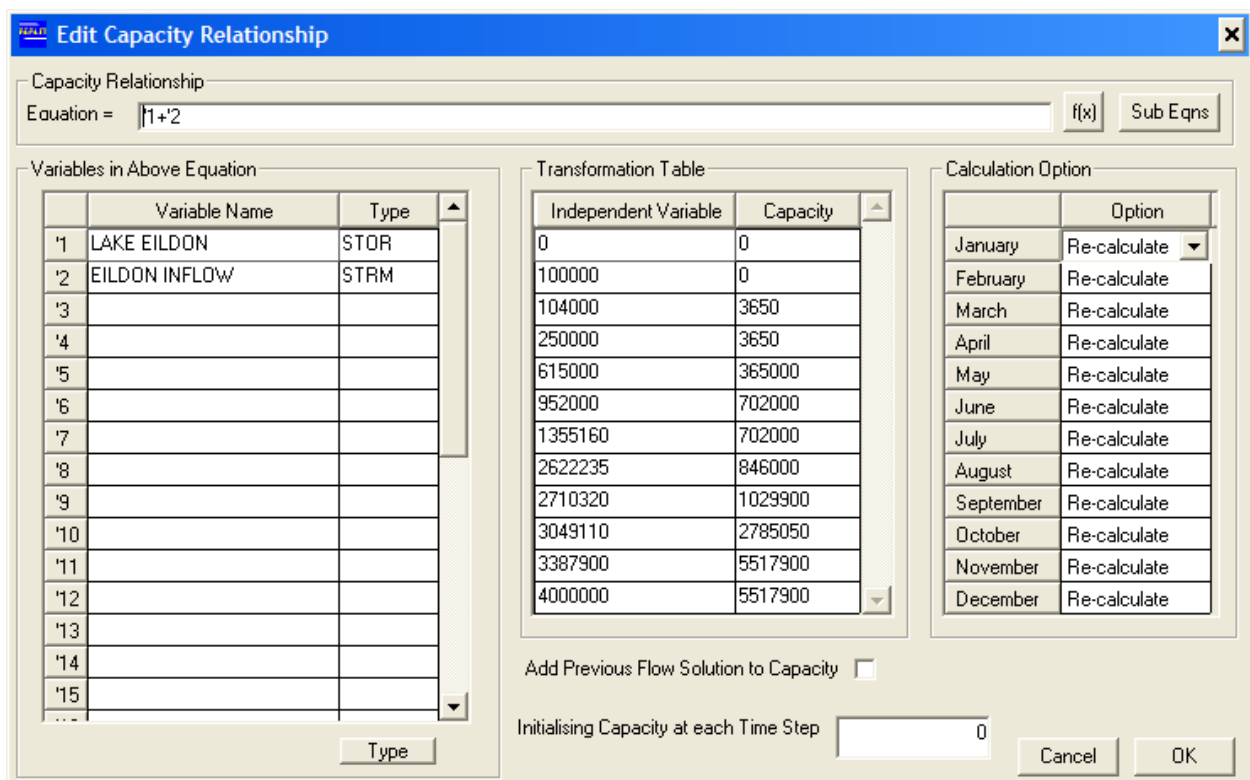


Figure 5-31 Edit Capacity Relationship Dialog Box

If variable names are not found, an error message of the form shown below is displayed:

No arc-capacity operator found for “big lake” type “SALN” see carrier

“outlet”.

The variable names (and type) then should be set again to correct values using the System Editor.

In all above cases of system variables (except in the case of carriers), the values for the simulation time step are fixed and therefore, no iterations are required in carrier capacity calculations. However, when the system variable is a carrier in the system file, the value of this system variable could change from one REALM iteration to another during a simulation time step, and require a number of iterations to converge to the correct capacity.

When the capacity of one carrier is dependent on the flow of another carrier, the capacity relationship is generally known as a “flow/flow (f/f)” relationship in REALM and flow/flow relationships require several iterations to converge.

When flow/flow relationships are used to compute the capacity of carrier, a trial solution must be found for the flows in independent variable carrier (REALM assumes a reasonable value for the first iteration) and then the capacity of the dependent carrier is computed. The simulation module then solves the flow in the network and then the capacities of the dependent carriers are recomputed. The simulation module re-solves the network and the flows are computed. This process continues until the convergence criteria are reached. The convergence criteria are specified by the user by changing the corresponding values in the *realm.set* file using the tab “Convergence/Iteration” of *Run::Options*, before setting up the simulation (i.e. use of REALM Setup S). The following convergence criteria are used in REALM in modelling the capacity of carriers based on flow/flow.

1. percentage difference in flow/flow dependent carrier capacities between two consecutive iterations less than a certain tolerance;
2. a maximum number of iterations.

The solution is considered as converged when one of the criteria is satisfied. The option (2) is used only to stop endless looping. If this occurs, a warning message related to non-convergence at this simulation time step is given in the simulation log file.

Transformation Table

A series of points (up to 12 pairs) describing the Independent Variable Capacity relationship is entered in the “Transformation Table”. These columns are not related to months. The ‘*Independent Variable*’ column represents the values of the independent variable of the relationship, while the ‘*Capacity*’ column represents the capacity of the carrier corresponding to the values of the independent variable. The transformation table should consist of a set of monotonically increasing ‘*Independent Variable*’ data points. During simulation run time, REALM extracts the value of the independent variables of the time step under consideration, computes the temporary variable (which will be then be considered as the independent variable) using the equation (Figure 5-31) and then computes the capacity of the carrier using the calculated temporary variable and the values of the transformation table, using interpolation.

Calculation Option

This column defines the way the variable capacity is computed for each month. The setting can be chosen from three options for each month. The functions of these values

are listed below:

Off makes the capacity zero

Previous use the preceding month's capacity

Re-calculate re-calculate the capacity using the equation and the values of the transformation table

By default, this setting is set to "Re-calculate".

Initialising Capacity at each Time Step and Add Previous Flow Simulation to Capacity

Generally, the user requires new capacities to be calculated for each iteration of each time step of the simulation for Variable Capacity carriers. However in some cases (especially if the independent variable is reservoir or total storage with the type ESTO – which is the end storage at each iteration), the capacity does not converge and it might even oscillate between two values. In this case, the capacity computed in a previous iteration requires adjustment. This can be done by ticking the check box 'Add Previous Flow Solution to Capacity'. If the check box is ticked, then it is necessary to enter a value in the 'Initialising Capacity at each Time Step' field as starting value of the capacity of this carrier for iteration 1.

Table 5-2 Available System Variables for Variable Capacity Carrier Modelling

Variable Name	Sub-group	Type	Type Description	Variable Name & Type	Remarks
Node name	Reservoir	STOR (=SSTO)	Start season storage with evaporation taken out	EILDON and ESTO	
Node name	Reservoir	ESTO	End season storage at the end of iteration		
Node name	Reservoir	LVLS (=SLVL)	Start water levels (via RV rating table) without evaporation taken out		
Node name	Reservoir	ELVL	End water levels (via RV rating table)		
Node name	Reservoir	SARE	Start (of time step) reservoir surface area		
Node name	Reservoir	EARE	End (of time step) reservoir surface area		
Node name	Reservoir	INFW	Inflow data from the streamflow file		
Node name	Reservoir	EVAP	Evaporation loss		
Node name	Reservoir	TARG	REALM calculated target value		
Node name	Reservoir	AWAT	REALM calculated available water for release value		
Node name	Reservoir	SPILL	Uncontrolled release over spillway		

<i>Variable Name</i>	<i>Sub-group</i>	<i>Type</i>	<i>Type Description</i>	<i>Variable Name & Type</i>	<i>Remarks</i>
Node name	Reservoir	RELS	Sum of water released		
Node name	Reservoir	RVSA	Flow in the spill arc (for debugging)		
Node name	Reservoir	SALN TURB COLR	Water quality default parameters in <i>realm.set</i> file or water quality	MOKOAN and COLR	MOKOAN is a reservoir in the system file.
Node name	Demand	UNRS	Unrestricted demand		
Node name	Demand	REST	Restricted demand		
Node name	Demand	SHRT	Demand shortfall		
Node name	Demand	RATN	Rationed demand		
Node name	Demand	LVLS	Demand restriction level		
Node name	Demand	SUPP	Demand actually supplied		
Node name	Demand	-DEM	Unrestricted demand of the previous months	GREENVALE and -DEM	GREENVALE is a demand zone name in the system and in a demand file.
Node name	Demand	-LVL	Previous month's restriction level		
Node name	Demand	-SHT	Previous month's demand shortfall		
Node name	Stream junction	INFW	Inflow data from the streamflow file	BIG RIVER and INFW	BIG RIVER is a stream junction in the system file.
Carrier name		FLOW	Carrier flow		
Carrier name		CAPC	Carrier capacity	COLIBAN RACE and CAPC	COLIBAN RACE is a carrier in the system file.
Carrier name		LOSS	Carrier loss		
Carrier name		-FLO	Flow in the previous month		
Carrier name		-CAP	Capacity in the previous month		
Carrier name		-LOS	Loss in the previous month		

<i>Variable Name</i>	<i>Sub-group</i>	<i>Type</i>	<i>Type Description</i>	<i>Variable Name & Type</i>	<i>Remarks</i>
Carrier name		RFxx	Sum of flows over the previous "xx" time steps. This Type is valid for any simulation time step.	MOKOAN OUTLET, and RF12 and RC60	MOKOAN OUTLET is a carrier in the system file. RF12 gives the sum of flows in this carrier over the previous 12 months and RC60 gives the sum of capacities over the previous 60 months.
Carrier name		RCxx	Sum of capacities over the previous "xx" time steps. This Type is valid for any simulation time step.		
Carrier name		AFxx	Sum of flow over a maximum period of previous 11 months from the current month up to the reference month of "xx" (reference and current month flows are not included). This sum is reset to 0 every 12 months in the first month after the reference month. This Type is valid only for monthly simulation time step.	MOKOAN OUTLET and AF05	MOKOAN OUTLET is a carrier in the system file. AF05 gives the sum of flows in this carrier over the previous 11 months, excluding May.
Carrier name		ACxx	Sum of capacity over a maximum period of previous 11 months from the current month up to the reference month of "xx" (reference and current month capacities are not included). This sum is reset to 0 every 12 months in the first month after the reference month. This Type is valid only for monthly simulation time step.		

<i>Variable Name</i>	<i>Sub-group</i>	<i>Type</i>	<i>Type Description</i>	<i>Variable Name & Type</i>	<i>Remarks</i>
Carrier name		{xxx	Sum of flow over the previous 'xxx' time steps; similar to RFxx, but allows for 3 digits (instead of 2). This Type is valid for any simulation time step.		
Carrier name		[xxx	Sum of capacity over the previous 'xxx' time steps; similar to RCxx, but allows for 3 digits (instead of 2). This Type is valid for any simulation time step.		
Carrier name		~xxx	Flow corresponding to a previous time step lagged by "xxx" time steps. This Type is valid for any simulation time step.		
Carrier name		@xxx	Capacity corresponding to a previous time step lagged by "xxx" time steps. This Type is valid for any simulation time step.	MOKOAN OUTLET and @060	MOKOAN OUTLET is a carrier in the system file. @060 is the capacity of the carrier at the previous 60th time step. Note: if the referred flow or capacity is corresponding to a time step before the first time step, zero is used for the system variable of flow or capacity.
Carrier name		SALN TURB COLR	Water quality default parameters in <i>realm.set</i> file	SMALL RIVER and TURB	SMALL RIVER is a carrier in the system file.
Keywords	TOTAL STORAGE	STOR (=SSTO)	Start season total storage	TOTAL STORAGE and ESTO	
Keywords	TOTAL STORAGE	ESTO	End season total storage at the end of iteration		

<i>Variable Name</i>	<i>Sub-group</i>	<i>Type</i>	<i>Type Description</i>	<i>Variable Name & Type</i>	<i>Remarks</i>
Keywords	TOTAL DEMAND	UNRS	Total unrestricted demand	TOTAL DEMAND and SUPP	
Keywords	TOTAL DEMAND	REST	Total restricted demand		
Keywords	TOTAL DEMAND	SUPP	Total demand actually supplied		
Keywords	YEAR	TIME	Run time dates such as year, month and season		
Keywords	SEASON	TIME			
Keywords	CURRENT MONTH	TIME			
Keywords	LINEAR	TIME			
Keywords	Streamflow	STRM	Inflow data from a streamflow file	EILDON INFLOW and STRM	EILDON INFLOW is a column name in a streamflow file.
Keywords	Demand	DEMD	Demand data from a demand file	ROCHESTER and DEMD	ROCHESTER is a column name in a demand file.
Constant		NUMB	Number	999999 and NUMB	Alternatively, this number can be entered directly in the equations.
Node and arc number	Physical & ECN Nodes	NECN	Nodal requirement		
Node and arc number	Physical carriers and ECN arcs	AECN	Flow		

Notes Related to Table 5-1

Reservoir Nodes:

During each iteration of the simulation, REALM computes the total system storage and then the preferred individual storage volume of each reservoir. This preferred storage volume is defined as the REALM computed target storage (TARG) for each reservoir. Similarly, in setting up the network for use in Network Linear Programming, REALM computes a temporary variable called “Available Water” (AWAT) for each reservoir as the difference of the sum of start storage volume and inflow to the reservoir, and the sum of end storage volume and evaporation losses (when evaporation is modelled using the default option of REALM – Figure 5-8).

Demand Nodes:

The unrestricted demand (UNRS) is generally the demand in the demand file. The unrestricted demand may be reduced as a result of implementing the REALM restriction policy with different restriction levels (LVLS) and the resulting demand is known as the restricted demand (REST). If there are no restrictions, the unrestricted and restricted demands are the same. The restricted demand may be further reduced if the total demand is higher than the total storage plus inflow. This reduced demand is known as the rationed demand (RATN). The rationed demand will equal the restricted demand if there is no rationing, which in turn will equal the unrestricted demand if there are no restrictions. The rationed demand is used in the REALM network in solving for flows in the system. Failure to satisfy the rationed demand leads to shortfalls (SHRT). The shortfalls are usually due to transfer constraints of the carriers. The amount of demand actually supplied (SUPP) is the rationed demand minus the shortfall.

Carrier Capacity:

When the capacity of a variable capacity carrier (i.e. the dependent carrier) is dependent on the capacity of another variable capacity carrier (i.e. the independent carrier), **then it is recommended that the carrier number of the dependent carrier is higher than the carrier number of the independent carrier.** The reason for this is that the capacities of variable capacity carriers are computed one at a time, searching for variable capacity carriers from the lowest carrier number to the highest number. If a variable capacity carrier is defined using a higher-numbered carrier, then it accesses a carrier capacity, which has not been calculated. However, in such situations, REALM uses one of the options for the capacity of the higher-numbered carrier, as listed below:

- Zero, if the capacity has not been calculated at all; this happens during the first iteration;
- Capacity calculated from the previous iteration for subsequent iterations.

Water Quality:

The water quality types are useful in specifying the operating rules related to flow rejection, mixing or periodic flushing. The reservoir names and carrier names can be accompanied by water quality types. The types depend on the pseudo water quality names in the *realm.set* file (or water quality tab in *Run::Options*). For example, the *realm.set* file may have the water quality parameters as:

w/qual name #1 SALN

w/qual name #2 TURB

w/qual name #3 COLR

Water quality pseudo names should not start with the letters “AF”, “AC”, “RC” and “RF”. This will result in a type conflict.

Summing and Previous Value Types RF, RC, AF, AC, {xxx}, [xxx], ~xxx and @xxx:

This group provides many useful tools for controlling operations. For example, it may be necessary to stop supply if the flow through a carrier over the previous 12-month period was greater than a certain quota. RF12 gives the total flow over the previous 12 time steps. Similarly, RC60 gives the total carrier capacity over the previous 60 time steps. RC60 can be used to compute the 5-year moving yearly average, by dividing the RC60 value by 5. **The RFxx and RCxx can be used with any simulation time step, such as daily or monthly.**

These Summing and Previous Value Types are applied only for carriers. To get the average storage volume for 12 months, it is necessary to use a (dummy) variable capacity carrier and set its capacity to track down the volume of the particular storage. This dummy carrier then will have storage volume assigned. Similar dummy carriers can be used to track down the averages on any other system variable (e.g. water quality levels of storages).

A variation on this theme is the “AFxx” and “ACxx” Types. These Types sum flows from a set month with an implicit reset to zero every 12 months. AF and AC refer to annual flows and capacities respectively. The “A” stands for annual totalling while “F” and “C” refer to carrier flow and capacity respectively. “xx” can be used to specify the reference month. During the reference month the variable returns the sum of the previous 11 months. The sum is set to zero in the first month after the reference month. The following example sums previous flows from (but not including) month of MAY:-

Name	Type
MOKOAN OUTLET	AF05

The above example gives the following flow sums over the 12-month period from June 2001 to June 2002.

Simulation time step	Flow sum over
June 2001	0 (reset)
July 2001	June 2001
August 2001	June - July 2001

September 2001	June - August 2001
October 2001	June - September 2001
November 2001	June - October 2001
December 2001	June - November 2001
January 2002	June - December 2001
February 2002	June 2001 - January 2002
March 2002	June 2001 - February 2002
April 2002	June 2001 - March 2002
May 2002	June 2001 - April 2002
June 2002	0 (reset)

The Types {xxx and [xxx can be used to replace RFxx and RCxx respectively. Usage of these special symbols allows 3 numeric digits to be entered instead of 2. **The Types {xxx and [xxx can be used with any simulation time step, such as daily or monthly.**

These summing Types can be used in multi-replicate runs. However, they cannot be used with restart runs as they do not acquire the totals from a previous run.

Type TIME:

The keywords "YEAR", "CURRENT MONTH", "SEASON" and "LINEAR" can be used with Type TIME to access the run time TIME variables such as year, month and season. The "LINEAR" keyword gives access to a time step counter (e.g. first time step of the simulation = 1). For daily and weekly time steps, the "CURRENT MONTH" returns a number from 1-12 representing calendar months, where as the "SEASON" returns the actual day or week number in the year. **These keywords must be in upper case.**

Examples:

Name	Type
YEAR	TIME
SEASON	TIME
CURRENT MONTH	TIME
LINEAR	TIME

Types related to system nodes and arcs:

The Types "AECN" and "NECN" can be used to access any nodal requirement or arc flows in the system of nodes and arcs converted by REALM corresponding to the physical network of nodes and carriers. The reader is referred to the following paper for theory of the conversion of the physical network to the network of nodes and arcs, and for definitions of nodal requirement and equivalent component network (ECN): "A generalised water supply simulation computer software package" by Perera, B.J.C. and James. B. A (2003).

The node or arc number should be specified in the variable name field. Changes to the network will cause specific ECN node and arc numbers to change. Therefore, this option is seldom used.

Examples:

Name	Type
365	NECN
8	AECN

5.6.4.5 SETTING UP AN EQUATION

The system variables should link with an equation to compute the variable capacities. As can be seen in Figure 5-31, each independent system variable (defined by 'Variable Name' and 'Type') is assigned a shorthand reference number (e.g. the first reference system variable is '1' and the second item is '2' and so on). These numbers can be seen on the left side of the 'Variable Name' column. These reference numbers can be mixed with operators and constants to write the equation.

When writing an equation, it is necessary to understand how REALM processes the equation. **The order of processing is from left to right (i.e. standard mathematical BODMAS is not used).** The bracket operator is included to control the precedence as in standard mathematical equations. Several functions (described later) are available to compute various parameters such as square roots, minima etc.

To set the capacity of a variable capacity carrier to a constant, leave the 'Variable Name' and 'Type' fields blank and enter the constant in the equation field.

During run time, REALM computes a temporary variable based on the values of the dependent variables and the equation, and uses this temporary variable to calculate the capacity of the carrier, by interpolation using the values in the transformation table (Figure 5-31).

Operators and Functions

The available operators include: + - / * ** ^ () !

The available mathematical functions are:

**EXP LOG LN ABS MIN MAX SQRT MOD COS SIN TAN RND IF P1 N1
INT NINT MTH**

These mathematical functions are case insensitive. Most of these functions are self-explanatory and the use of these functions can be seen in the following examples.

Examples:

```
'1-2+(2300/4)-5/24
```

```
((exp('1)+min(5000,'2','3'))/(LOG('5/24))*sqrt(97)
```

Note: A comma “,” cannot appear in front of a function. That is, the equation **min(2000,sqrt('1))** is not valid. Instead, the equation should be written as **min(2000,(sqrt('1)))**. Functions without arguments such as **rnd()** or **if()** are ignored.

MTH() Function

The **mth()** function requires the user to enter 12 values (or arguments), either as constants or system variables, one value corresponding to each month of the year, starting from January. An error is generated during run time, if there are not 12 arguments. The function extracts the value corresponding to the current month during run time.

Examples:

```
mth(1200,1200,3000,0,0,4000,4000,5000,10000,120000,3000,1200)
```

```
max(5500,(mth('1','1','2,0,0','3','3','4','5,12000','2','1')))/12
```

IF() function

The **IF()** function consists of four parameters. An error is generated during run time, if the number of arguments is not equal to 4.

The first parameter defines the “test” condition.

If the first parameter is negative or evaluates to a negative value, the result of the **IF()** function will be the second parameter.

If the first parameter is zero or evaluates to zero, the result will be the third parameter.

Finally, if the first parameter is positive or evaluates to a positive value, the result will be the fourth parameter.

Examples:

```
IF(10,1,2,3)
```

The test condition (i.e. 10) is positive and therefore the result of the equation is 3.

```
IF((2000-'1),1000,0,500)/5
```

The above example uses a run time variable '1' as part of the test. Depending on the result of (2000-'1) (re-evaluated at each iteration of each time step), the result of the equation will be either 200 or 0 or 100. In this example, the IF() function returns initially either 1000 or 0 or 500, but the result has to be divided by 5. As shown in this example, the IF() function can be used in conjunction with other operators.

A further example:

```
5000/'1-SQRT('2)+(IF('3,10,20,30)/(MIN('4,10)))
```

N1() and P1() functions

The function **N1()** returns a 1.0, if the argument is negative. Otherwise, it returns a zero.

The **P1()** function returns a 1.0 if the argument is positive. Otherwise, it returns a zero. These functions are useful in setting up switches and triggers.

Examples:

```
N1(10)*9999999
```

In the above example, **N1(10)** gives a zero, and therefore the result of the equation is zero.

```
N1(-10)*9999999*P1(10)
```

In the above example, the result is 9999999, since the argument of **N1()** is negative and the argument of **P1()** is positive. Both **N1(-10)** and **P1(10)** give 1.0.

```
P1(5000-'2)*2000
```

In the above example, if the value of the system independent variable represented by the reference number '2' is greater than 5000, **P1()** evaluates to zero and the equation then returns a zero. On the hand, if '2' is less than 5000, then **P1()** evaluates to 1 and the equation returns 2000 as the result.

RND(0) Function

This function generates a random number between 0 and 1.0. An argument must be supplied (e.g. **rnd(0)**), but the value of the argument is not important. The *realm.set* file contains an entry "random seed" to control the seed. If this entry is set to 0 or 1,

different random number sets are generated each time **rnd(0)** is used, while any other number will fix the random number set.

Examples:

```
2000+200*rnd(0)
```

The above example generates a random number between 2000 and 2200.

INT() & NINT() Functions

The equation parser in REALM always computes real numbers. The functions **INT()** and **NINT()** convert real numbers into integers. The resultant integer number is then converted back to a real number as the final result at the end of operations in the equation. The function **INT()** rounds down to its integer part, while **NINT()** rounds off to the nearest integer.

Comment operator "!"

To add a comment directly into the equation field, "!" should be placed at the end of the equation text. Entries following the "!" are ignored. The "!" is useful where the equation determining the capacity of a carrier has changed, and the user wishes to retain the old equation as a comment. (Do not confuse the use of the ! in REALM with the use of the exclamation mark in mathematics to denote the factorial operation.)

Examples:

```
N1(10)*9999 + '1/10-sqrt(2) ! this is a test case only
```

Use of Brackets

The REALM equation parser uses simple rules. It does not use the standard BODMAS rule. Although it is simple, the complex equations can be formulated based on the following rules:

1. The equation is processed from left to right. However, the contents within brackets are computed first, as in standard mathematical expressions.

```
1+2*3 ! result is 9 not 7
```

However, the equation **1+(2*3)** will result in 7.

2. If there are expressions within functions (e.g. in **min()**, **max()**, **mth()**, **if()** etc.), brackets must be used.

```
Min(8,7,6,2+10) ! result is 2 (the +10 is ignored)
```

However, the equation **min(8,7,6,(2+10))** will result in 6.

3. Functions within functions must be written within brackets.

```
Min('1,2,if('3,100,200,300)) ! this will not work
```

In the above example, the **if()** should be within brackets. It should be written as **min('1,2,(if('3,100,200,300)))**. In this equation, first **if()** is computed and returns a single value either 100, 200 or 300. This value is then used in **min()**.

if('3,min('1,1000,'2),200,300) ! this will not work

It should be **if('3,(min('1,1000,'2)),200,300)**.

Calculator utility (Section 8.5)

The REALM *Calculator* utility has the same functionality as the equation parser in REALM in computing capacity of variable capacity carriers. The users can use the *Calculator* utility to test the equations that will be used in variable capacity carriers.

5.6.4.6 SUB-EQUATIONS

Entering Sub-equations

Sub-equations are accessed via the **Sub Eqns** button within the “Edit Capacity Relationship” dialog box for variable capacity carriers (Figure 5-32).

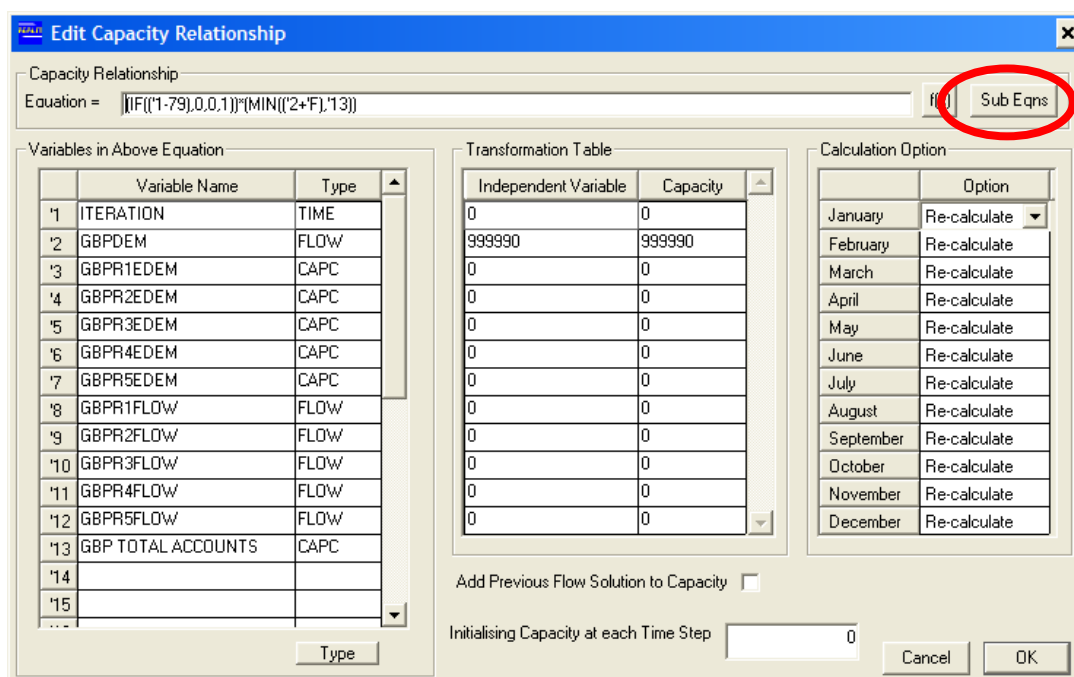


Figure 5-32 Edit Capacity Relationship Dialog Box

The “Sub Equations Editor” dialog box is shown in Figure 5-33. The left hand side of the dialog box shows the same list of variable names and types from the main “Edit Capacity Relationship” dialog box. This list can be edited in either the “Sub Equations Editor” or the “Edit Capacity Relationship” dialog box, but will remain the same for both. Up to 30 variable names and types can be entered. Refer to Section 5.6.4.4 for more information on entering variables.

The ‘Primary Equation’ is also shown in the “Sub Equations Editor” dialog box. This is the same as the equation shown in the ‘Equation’ field in the “Edit Capacity Relationship” dialog box, and is the final calculation that sets the overall capacity of the carrier for each iteration of each time step. The primary equation can be composed of variables (referenced using the ‘1 to ‘30 labels) and sub-equations (referenced using the ‘A to ‘ZZ labels).

The sub-equations are listed below the primary equation. Up to 702 sub-equations referenced using labels from 'A' to 'ZZ' can be entered. Normal syntax rules for REALM equations apply when specifying the sub-equations. There cannot be blank sub-equations above defined sub-equations. For example, if sub-equation B has been entered, sub-equation A cannot be blank and an error message will be produced stating: "Blank or null equation encountered in variable capacity carrier [name]. Check Carrier [No.]. Sub-equation A".

Each sub-equation also includes space for a detailed comment immediately to the right of the equation. For clarity, only the first 54 characters of the comment are shown in the dialog box. The remainder of the comment can be viewed/edited by either scrolling through the text or pressing the 'Show' button immediately to the right of the comment. Pressing this button opens another dialog box for easy viewing and editing of long comments.

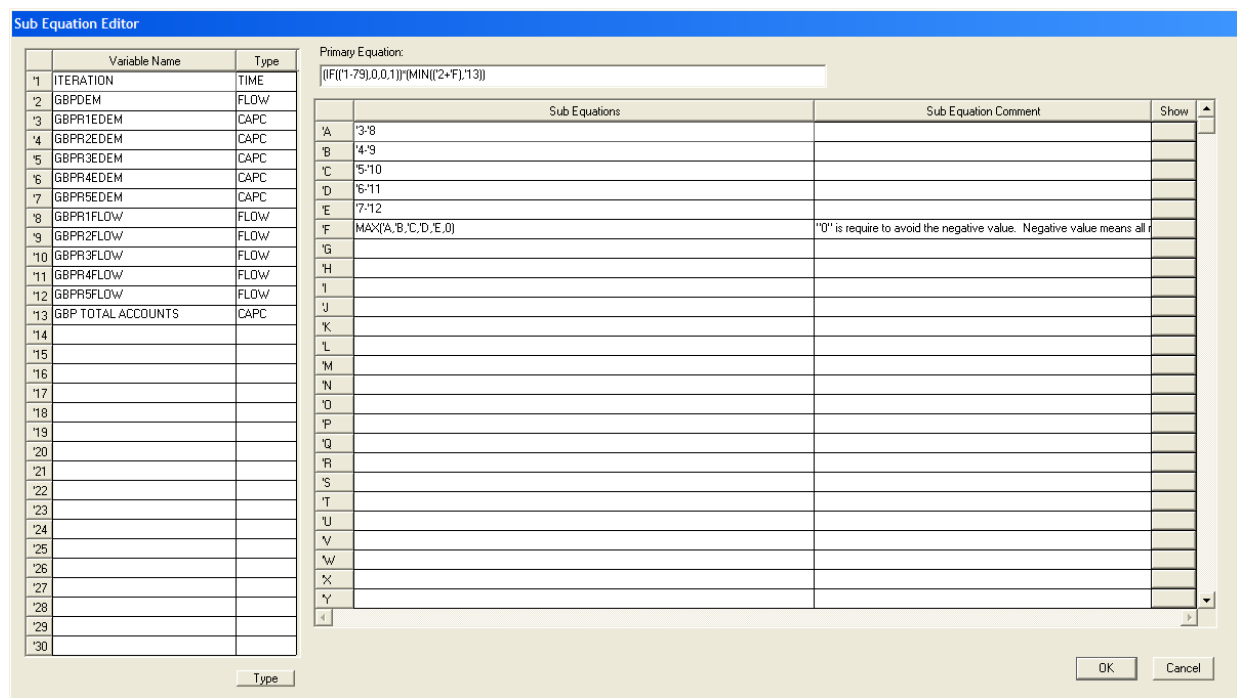


Figure 5-33 Sub Equations Editor Dialog Box

Sub-equation Calculation

Calculation of sub-equations is undertaken using the standard REALM equation syntax and rules. Sub-equations are calculated in the order shown in the dialog box (ie starting at 'A', then 'B', through to 'ZZ'), with the primary equation calculated last and used to set the capacity of the carrier (via the transformation table). This is of importance when using sub-equations to separate out complex parts of the overall carrier capacity.

Sub-equations can directly reference any of the other sub-equations which are calculated before them. For example, sub-equation B can refer to sub-equation A, but sub-equation A cannot refer to sub-equation B.

Another example is shown in Figure 5-33. The sub-equations represent parts of a more complex overall equation, which allows these component parts to be documented and output separately. The final sub-equation ('F') references sub-

equations 'A to 'E and the primary equation references sub-equation 'F.

Sub-equation Cross Referencing

In addition to referencing other sub-equation results within the same carrier and same time step as described above, it is also possible to reference the value of sub-equations in other carriers in the current time step. It is also possible to reference sub-equation results from any carrier in previous time steps. When referencing the sub-equation results of other carriers it is very important to note the order of the carriers. As for any reference in REALM to the capacity of another carrier in the current time step, the numbering of the carriers is very important. **A reference to a lower numbered carrier will result in the value from the current iteration being used. Referring to a higher numbered carrier will result in its value from the previous iteration being used.** For this reason it is very important to check that all cross referencing is referring to the intended result and that the model results are stable from iteration to iteration.

The naming convention used to refer to any sub-equation result is described below.

Variable Name	Type	Description
Carrier 1	nn_A	The result for sub-equation A of carrier 1 for previous time step lagged by "nn" time steps
Carrier 2	nnZZ	The result for sub-equation ZZ of carrier 2 for previous time step lagged by "nn" time steps

An example is shown in the table below.

Variable Name	Type	Description
Carrier 3	00_A	The result for sub-equation A of carrier 3 for previous time step lagged by 0 time step (i.e. current time step)
Carrier 4	99ZZ	The result for sub-equation ZZ of carrier 4 for previous time step lagged by 99 time steps

If the user references a time step that does not exist, for example in time step 2 refers to a sub-equation result from 12 time steps ago, the result will be zero and no error message is produced.

Sub-equation Output

Refer to Section 6.6.1.

5.6.4.7 CARRIER WATER QUALITY PARAMETERS

By selecting the "Water Quality" tab of the Add/Edit Carrier dialog box (Figure 5-28), the user can specify the parameters of water quality for this particular carrier (Figure 5-34). As mentioned in Section 5.4.4.5, four water quality parameters can be modelled with the current version of REALM. They are termed as *ec*, *Turb*, *Siva* and *Norm* in

Figure 5-34, but can be changed by changing these parameters in the *realm.set* file, through the “Water Quality” tab of *Run::Options*.

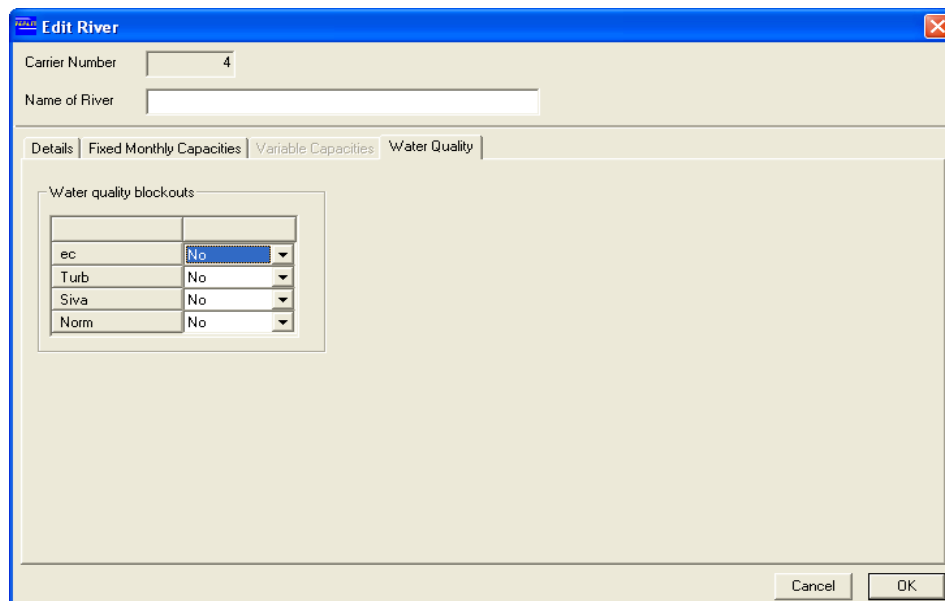


Figure 5-34 Water Quality Parameters Menu for Carriers

Figure 5-34 can be used to block out certain flow paths for water quality modelling (i.e. water quality calculations are turned off for blocked out water quality parameters). The default is ‘No’ which specifies that water quality would be modelled in this carrier. This option might be useful to model water quality immediately downstream of a treatment plant, where water quality can be considered to have zero concentrations (for the carrier immediately downstream of the treatment plant).

5.7 DEMAND RESTRICTIONS


It is a common practice to reduce the demands during periods of low storage and streamflow. There are two types of demand restrictions that can be modelled in REALM, namely:

1. Urban restrictions which apply to urban/industrial demand zones;
2. Irrigation (or rural) restrictions which apply to irrigation demand zones.

It should be noted that the urban/industrial and irrigation (or rural) demand zones are configured in REALM through DC1 (Urban Demand) and DC2 (Rural or Irrigation Demand) nodes respectively, and hence, can be restricted separately during low storage.

To implement demand restrictions:

Click on the *Edit::Restrictions* menu item or

Click on the  ‘*Edit Restrictions*’ button on the toolbar of the System Editor window (Figure 5-1).

The “Restrictions” dialog box (Figure 5-35) is displayed.

5.7.1.1 RESTRICTIONS AND DEMAND GROUPS

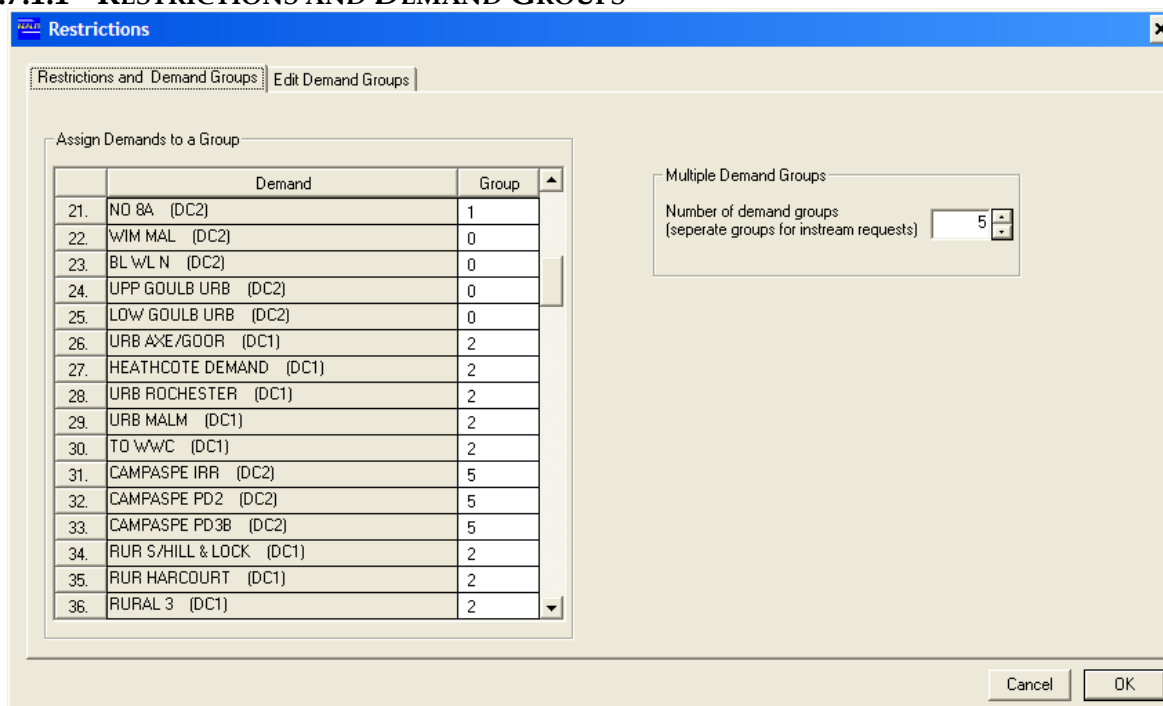


Figure 5-35 Restrictions and Demand Groups Tab of Restrictions Dialog Box

Assigning demands to multiple groups allows the user to model several independent demand groups, each group having its separate restriction demand parameters. In this case, each group undergoes restrictions at different times under different severities.

To assign Demands to Groups

Click on “Restrictions and Demand Groups” tab in the “Restrictions” dialog box (Figure 5-35) to enter the restriction details of each group.

The number of demand groups is set using the drop down box ‘Number of demand groups’ in the “Multiple Demand Groups” block (Figure 5-35). [Ignore the text ‘separate groups for instream requests’ – it is an artefact of earlier versions of REALM.] The default number of demand groups is 1. Use the arrows next to the drop down box to enter the desired number of demand groups. In Figure 5-35, the user has specified 5 demand groups.

All of the demand nodes and their type (DC1 or DC2) are listed in the ‘Demand’ column of the “Assign Demands to a Group” block (Figure 5-35). . Initially, the ‘Group’ column will be populated with a ‘0’ next to each demand, indicating that no demand has been assigned to a restriction group yet.

Click on the cell in the ‘Group’ column to be edited. A drop down box will appear will the numbers 0,1,2,3...up to the number entered in the ‘Number of demand groups’ field. (The value ‘0’ is used for a demand node if it is not to be restricted.) Assign each demand to a group. Urban and irrigation demands should be put in to separate groups, although there can be more than one group for urban/industrial demands and more than one group for irrigation demands. In the “When defining restriction parameters, it is possible to define the restriction details of each group of demands by

the storage level of one reservoir or a combination of reservoirs. This flexibility is useful for systems where only certain reservoirs supply certain demand zones.

5.7.1.2 EDIT DEMAND GROUPS

Click on “Edit Demand Groups” tab in the “Restrictions” dialog box (Figure 5-35) to enter the restriction details of each group.

Assign Reservoirs to a Demand Group:

All reservoirs defined in the system file are displayed as rows in the ‘Assign Reservoirs to a Demand Group’ list and the demand groups as columns. By ticking the appropriate check boxes, the reservoirs can be assigned to one or more Demand Groups. Storage volumes in these reservoirs in the group trigger the restrictions.

Edit Restriction Policy:

Select the demand group to be edited using the ‘Demand group’ drop down box in the “Edit Restriction Policy” block (Figure 5-36 and Figure 5-41).

The text to the right of the ‘Demand group’ drop down box will read either “DC1-Urban” or “DC2- Rural”, indicating the type of demand group selected. **The fields visible in the “Edit Restriction Policy” block change depending on the type of demand group (DC1 or DC2) and how restriction policy is set (by Menu or Carrier).**

Then click on the appropriate radio button to select how restrictions are to be modelled (i.e. via Menu or Carrier).

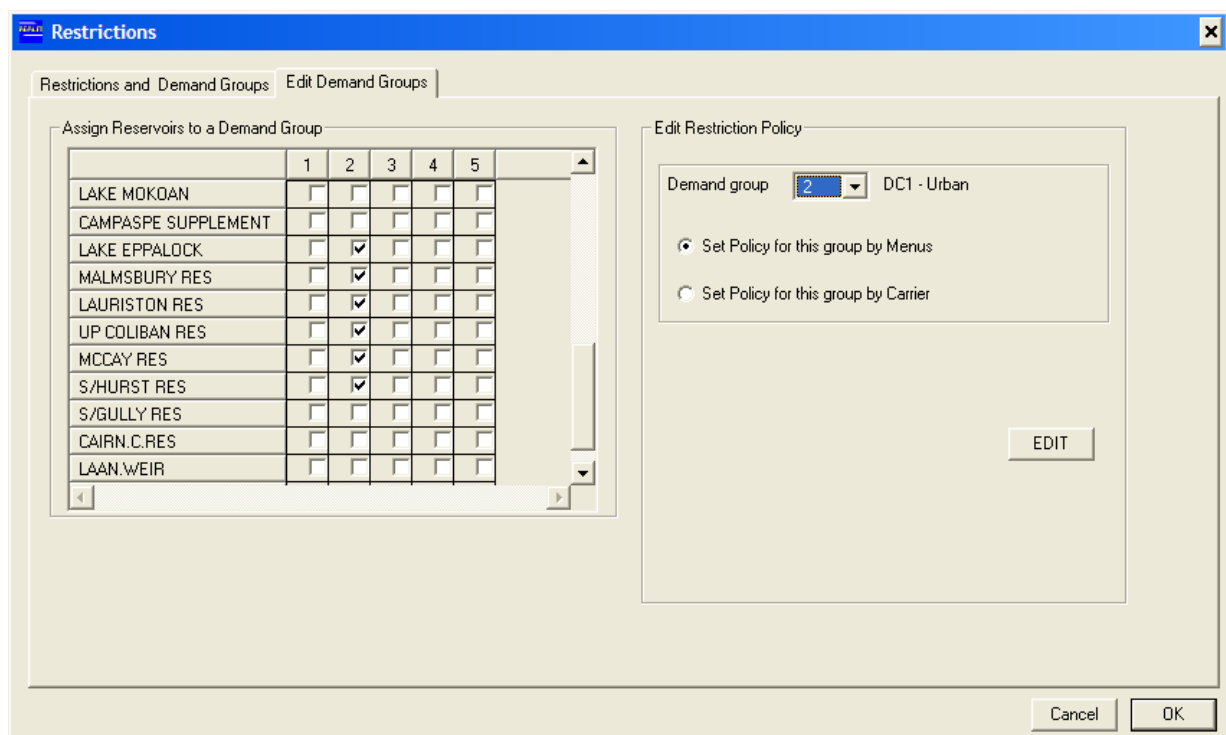


Figure 5-36 Edit Demand Group Tab of Restrictions Dialog Box (DC1 -Urban demand)

5.7.1.3 URBAN/INDUSTRIAL (DC1) RESTRICTIONS BY MENU

Figure 5-36 shows the selection for this case, where DC1 urban demand nodes are

considered in the demand group and restrictions are to be modelled by Menus. Note that the demand group 2 is being edited in Figure 5-36.

Click on the **EDIT** button in the “Edit Restriction Policy” block (Figure 5-36). This will display the dialog box as shown in Figure 5-37, which features Menus that enable the user to enter the required demand restriction parameters for this group, such as the base demand, the lower rule curve, the upper rule curve and the details of intermediate restriction zones of urban/industrial demand.

Urban Restriction Rule Curve Details:

The rule curves (i.e. lower and upper curves) trigger the restrictions and are expressed in terms of the total system storage of the reservoirs assigned to the demand group. The base demand (the column ‘Base’) and the rule curves (the columns ‘Lower’ and ‘Upper’) can be entered either as percentages of Average Annual Demand (AAD) or as absolute values. In the latter case, the base demand and the rule curves are entered with a preceding negative sign (or entry is negative).

Hit the **View Restriction Curves** button to view the restrictions in graphical form.

Rule Curves as a Percentage of AAD

When the rule curves (i.e. upper and lower curves) and the base demand are expressed in terms of AAD, the trigger levels of restriction rule curves increase with increasing demand over the planning period. This type of restriction rules are used for urban water supply systems with growth in annual demand. The total system storage is computed at the start of the simulation time step by summing up the storage volumes of the reservoirs nominated for the demand group. This volume is then converted as a percentage of AAD and compared with the restriction triggers defined by the rule curves to impose restrictions. For example, if the total system storage is above the values defined by the upper rule curve, no restrictions are imposed. If it is below the values defined by the lower rule curve, then the restricted demand becomes the nominated base demand (which is generally the household demand). If the total system storage is in an intermediate zone (described later), then the demand is restricted by the corresponding percentage (i.e. Percentage Restrictable) of the intermediate zone; in this case only the demand above the base demand is restricted by this percentage.

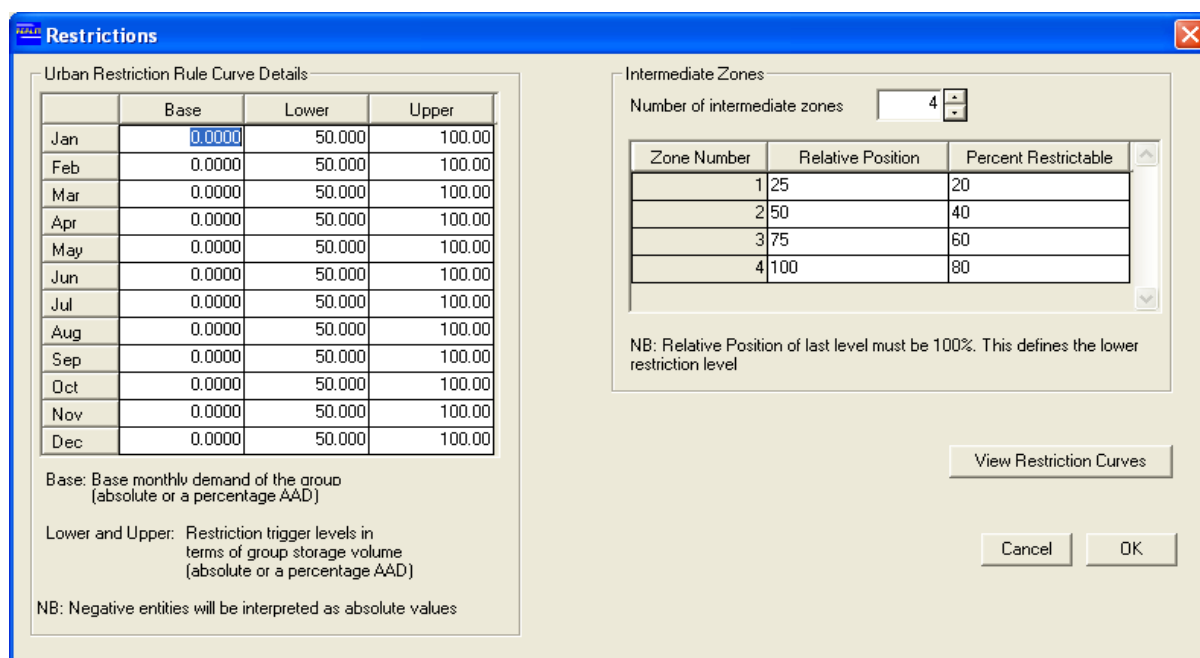


Figure 5-37 Edit Restriction Curve Parameters Dialog Box for DC1 Group

Note that if the reservoir evaporations are modelled through the default option described in Section 5.4.4.3, the total system storage at the beginning of the month has already subtracted the reservoir evaporation for the particular month, and this total system storage is used to trigger the restrictions.

An entry of 100% for the upper rule curve means that the reservoirs in the demand group should have a volume at the beginning of the month that is less than one year’s demand to trigger restrictions. When expressing the base demand in terms of percentage of AAD, the sum of base demands with respect to the months of this year should be less than 100%. If the sum is 100%, then the base demand is equal to the unrestricted demand.

Rule Curves in Absolute Values

When the base demand and the rule curves are expressed as absolute values, the total system storage is computed at the start of the simulation time step by summing up the storage volumes nominated for the demand group. This volume is compared with the restriction triggers defined by the rule curves to impose restrictions. Note that if the reservoir evaporations are modelled through the default option described in Section 5.4.4.3, then reservoir evaporations (for the particular time step) have already been subtracted from the total system storage at the beginning of the time step, and this total system storage is used to trigger the restrictions.

Intermediate Zones

The intermediate zones can be used to impose different restriction levels of varying degrees of severity. Figure 5-38 shows a schematic diagram of typical restriction rule curves used by urban water authorities. The restriction triggers in this figure can be considered in the form of percentage of AAD or in absolute values. The upper and lower rule curve, the base demand, four intermediate restriction levels and zones are also shown in the figure. The lower rule curve in this figure is shown to have a constant value for each month, although if it is not a necessary requirement.

The “Intermediate Zones” block in the “Restrictions” dialog box (Figure 5-37) allows user to enter the details of the immediate zones. In this figure, four intermediate zones are considered. These intermediate zones are consistent with Figure 5-38. As can be seen from Figure 5-37, the ‘Relative Position’ of the last level must be 100%, which defines the lower rule curve.

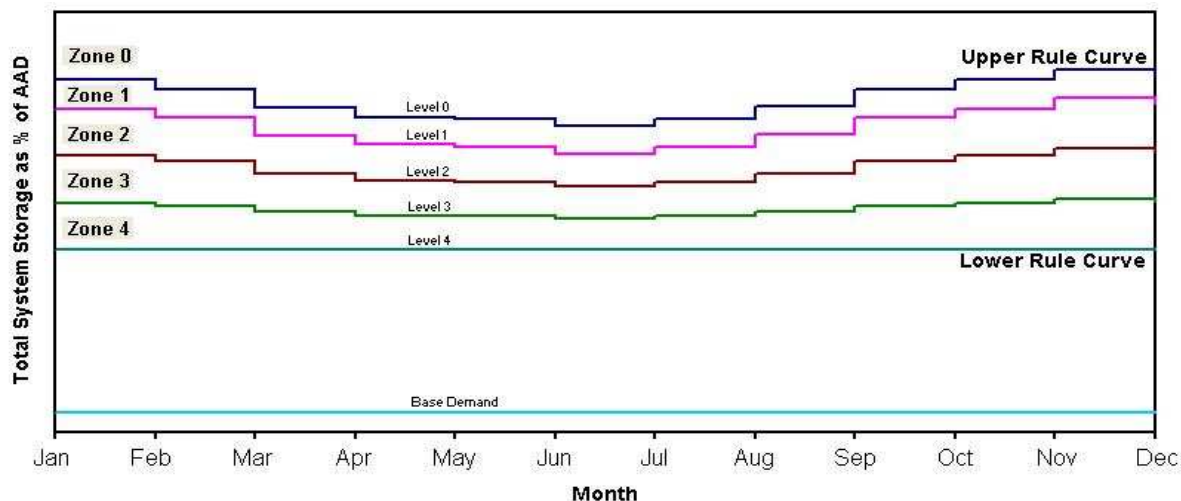


Figure 5-38 Typical Urban Restriction Rule Curves

The Relative Position defines the intermediate restriction level as a percentage of the difference of upper and lower rule curves, from the upper rule curve. Therefore, the Relative Position of Level 4 must be 100. As mentioned earlier, only the restrictable demand (i.e. component of the demand between unrestricted and base) is restricted by the Percent Restrictable relevant to the restriction zone. Table 5-3 shows the details of restriction zones for a typical urban restriction policy, which consists of 4 intermediate zones, which is also consistent with Figure 5-37 and Figure 5-38. Note that ‘Relative Position’ defines the lower boundary of the restriction zone.

Table 5-3 Details of Restriction Zones for a Typical Urban Restriction Policy

Restriction Zone	Restriction Zone Defined by Level	Relative Position (%)	Percent Restrictable Demand
0	above 0	0	0
1	0-1	25	20
2	1-2	50	40
3	2-3	75	60
4	3-4	100	80
5	below 4	-	100

As can be seen from Table 5-3, it is possible to assign a different level of reduction for each intermediate zone. This allows severe restrictions to be imposed, as the total system storage falls progressively. Similarly, the zones can be defined with uneven Relative Positions, although the values shown in Table 5-3 show even intervals.

The above details need to be entered for each urban/industrial demand group that requires demand restrictions during low storage and low streamflow periods, and modelled through Menus.

5.7.1.4 URBAN/INDUSTRIAL (DC1) RESTRICTIONS BY CARRIER

Click on the radio button ‘Set Policy for this group by Carrier’ in the Restrictions dialog box after selecting a demand group which consists of only DC1 nodes as in Figure 5-39. Note that this operation displays an additional field with the heading of ‘Name of Carrier’. Enter the Name of Carrier or select the Name of Carrier through its combo box list, which models the restrictions. This carrier is a variable capacity carrier, which computes the capacity of the carrier as the required restriction level for the simulation time step.

Click on **EDIT** button, which displays the message shown in Figure 5-40. As noted in Figure 5-40, when restrictions are modelled through a carrier, only the base demand and the Percent Restrictable of the intermediate restriction zones will be used in modelling of urban restrictions.

Click on **OK** to Figure 5-40, which displays the dialog box shown in Figure 5-37. This allows the user to enter the base demand and the details of intermediate restrictions. Note that the user is not required to enter any details on the lower and upper rule curves.

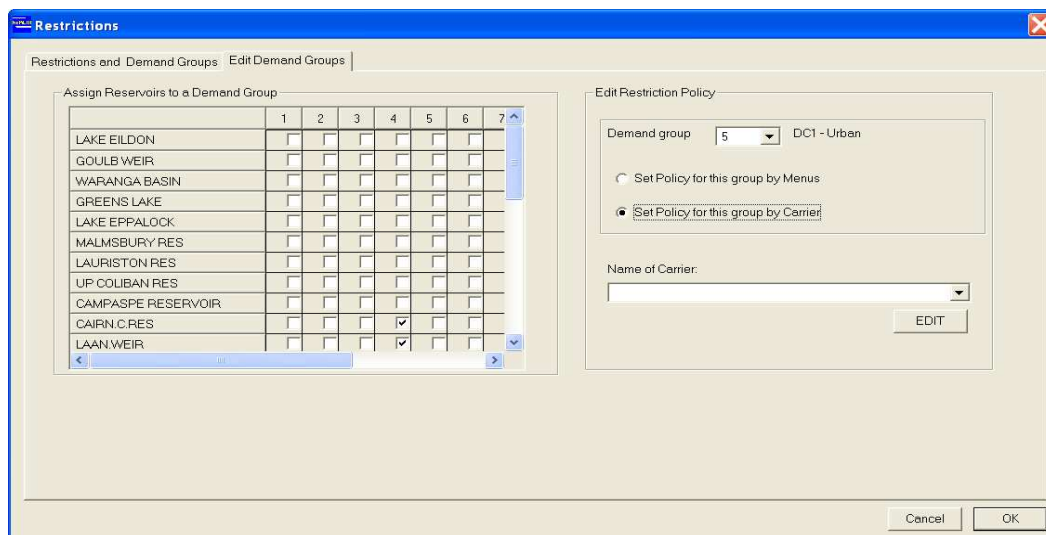


Figure 5-39 Modelling Urban/Industrial Restrictions Through a Carrier

During simulation, REALM computes the restriction level for the simulation time step using the information given in the variable capacity carrier, and then uses the information on Figure 5-37 to compute the restricted demand.

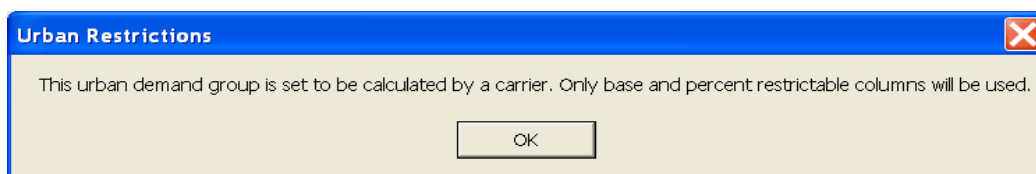


Figure 5-40 Message Showing Urban Restriction Modelling Through a Carrier

5.7.1.5 IRRIGATION DEMAND RESTRICTIONS BY MENU

In the “Edit Demand Groups” tab, under the “Edit Restriction Policy” block, enter the relevant demand group in the ‘Demand group’ field, using the the drop down list (Figure 5-41). In Figure 5-41, Demand group ‘1’ has been selected for editing. Note the text ‘DC2- Rural’ appears next to the ‘Demand group’ drop down box, indicating that the demand group selected consists of irrigation nodes.

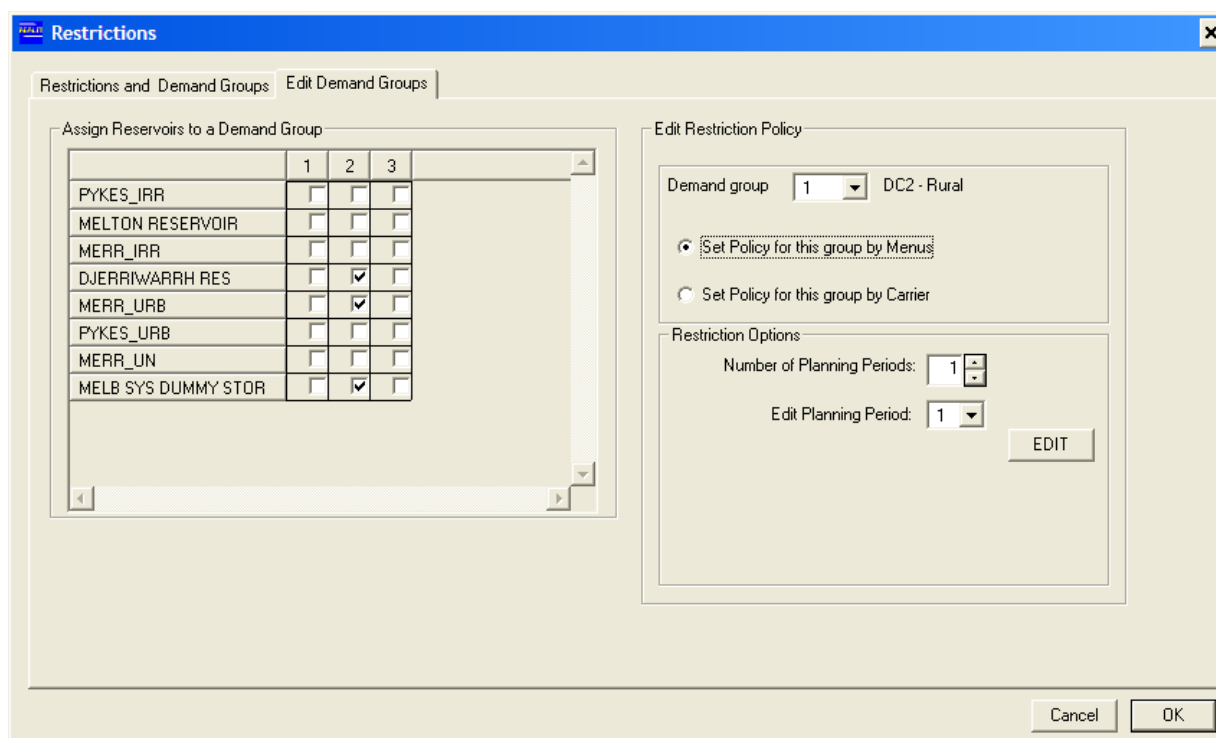


Figure 5-41 Edit Demand Groups Tab of Restrictions Dialog Box (DC2 - Rural demand)

Click on the radio button ‘Set Policy for this group by Menus’, which displays the “Restriction Options” block.

Type or use the arrow keys to enter a number in the ‘Number of Planning Periods’ field. Select the planning period to be edited using the “Edit Planning Period” drop down box and click on **EDIT**. This displays Figure 5-43, which allows the user to enter/edit information for this irrigation planning period.

Planning Period (Figure 5-43)

Several planning periods can be considered in the resources assessment. These planning periods can consist of just one irrigation season (one year planning period), two irrigation seasons (two year planning period), or many irrigation seasons (several year planning period). The information related to allocation season, forecast inflows,

reservoir evaporation, carrier losses and fixed adjustments, allocation curve and positive/negative mid allocation changes should be entered for each planning period.

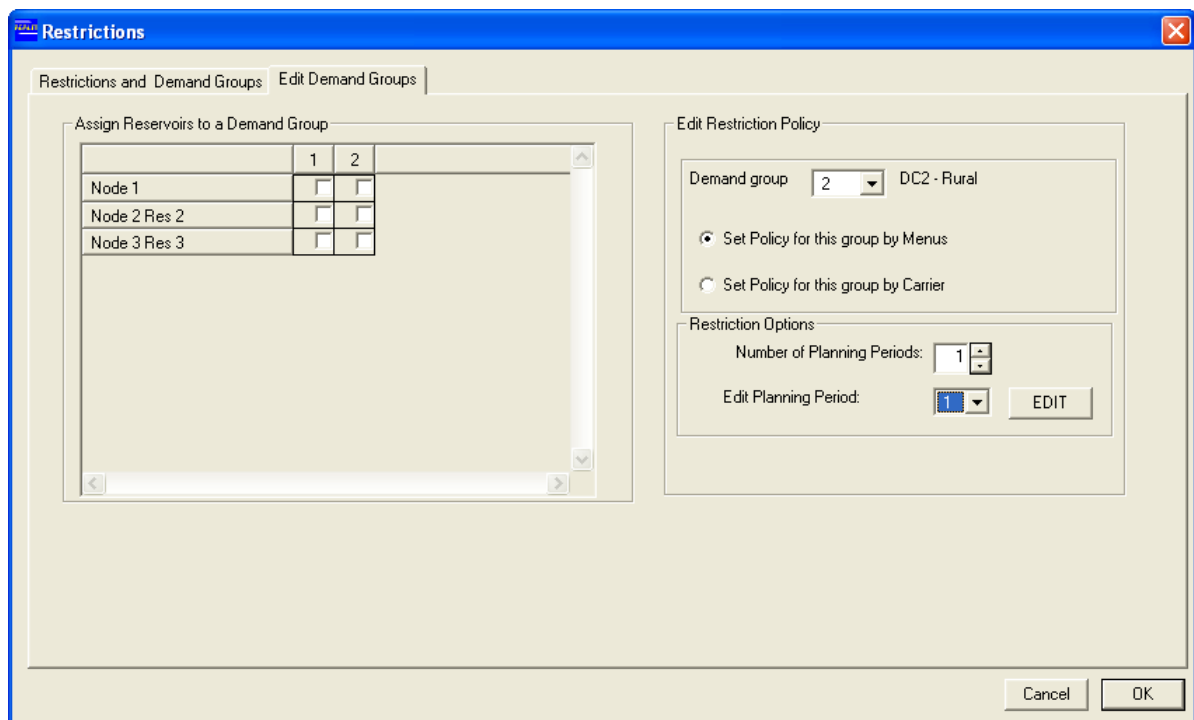


Figure 5-42 Edit Restriction Policy Dialog Box for a Rural Demand Group

Allocation Season (Figure 5-43)

The beginning (e.g. 'Jul') and end (e.g. 'Jun') of the irrigation (allocation) season are specified here. It should be noted that the season in this context refers to the irrigation season.

Maximum Allocation to be used for Unrestricted Demands (Figure 5-43)

This field allows the user to enter the maximum allocation that would be used for the demand group. These will not be any restrictions under the maximum allocation.

Efficiency for Group Delivery (Figure 5-43)

The supplied water to an irrigation (or urban for that matter) demand group is always greater than the water usage due to inefficiencies in the system because of transmission losses, operational losses etc. Therefore, the efficiency should be included to compute the actual deliveries from the headwater structures (e.g. reservoirs) to supply the demand.

Forecast Inflows, Reservoir Evaporation, Carrier Losses and Fixed Adjustments (Figure 5-43)

The forecast inflows can be the minimum flows, the percentage probability exceedance (e.g. 99%) flows or other assumed monthly inflows. The forecast reservoir evaporations and carrier losses are treated similarly to the forecast inflows. The fixed adjustments are all other quantities that should be included in the resource

assessment other than the forecast inflows, the reservoir evaporations and the carrier losses. One example is the commitments to other demand groups or instream flow requirements. The forecast inflow, reservoir evaporation and carrier losses should be specified for each month (which can be zero) as the total from this month to the end of the irrigation season. These parameters are used for the resource assessment in computing the available water for allocation.

The forecast inflows are always positive numbers. The forecast reservoir evaporation and carrier losses are generally positive numbers. However, the fixed adjustments can be either positive or negative numbers.

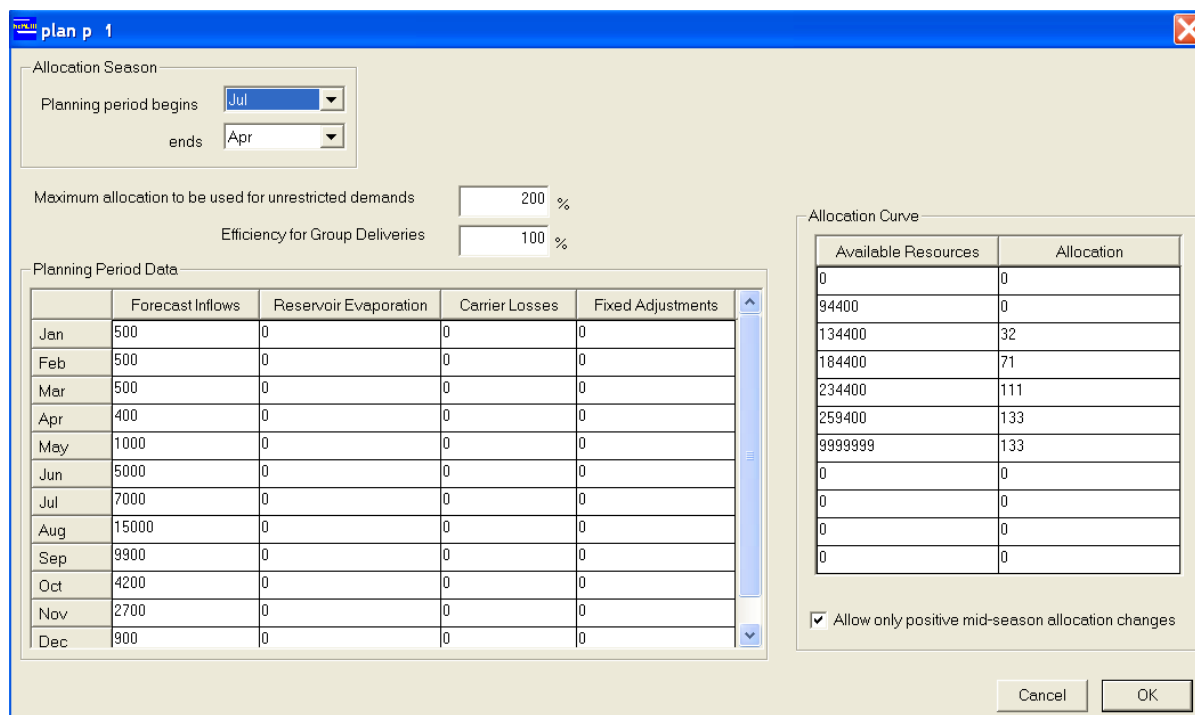


Figure 5-43 Editing Dialog Box for Irrigation Planning Periods

Allocation Curve (Figure 5-43)

The allocation curve defines the “percentage-announced” allocation corresponding to the available resource. This curve is developed from the recorded irrigation deliveries of the demand group based on irrigation deliveries (after adjusting by the delivery efficiency of the group). The allocation curve is defined as at start of the irrigation season.

Once the available water for release is computed from Equation 5.8 and “brought forward” to the starting month of the irrigation season, this available water is then used to compute the percentage allocation by interpolation, using the values of the allocation curve.

Note that the percentage allocation of the irrigation demands is the equivalent of the restriction level of urban/industrial demands.

Allow only Positive mid-Season Allocation Changes (Figure 5-43)

Generally, within irrigation seasons, as the season progresses allocations are not

allowed to reduce. Ticking the check box '*Allow only positive mid-season allocation changes*' ensures that the allocations are never reduced during the mid-season. If the user wishes to investigate the effect of reduced mid-season allocations, this check box can be left blank.

Resource Assessment and Allocation

The storage volumes of reservoirs in the demand group at the start of the month, the forecast inflows, reservoir evaporations, carrier losses, and fixed adjustments from the current month to the end of the irrigation season are considered in the resource assessment for each simulation time step in REALM. The available water for release is computed based on this resource assessment and given by the following equation.

$$\begin{array}{rcl}
 \text{Available Water} & = & \text{Total system storage (of this demand group)} \\
 & + & \text{Forecast inflows} \quad + \quad \text{Fixed adjustments} \\
 & - & \text{Reservoir evaporation} \quad - \quad \text{Carrier losses}
 \end{array}$$

5.8

The computed Available Water is then “brought forward” to the starting month of the irrigation season by the adding usage from the start of the irrigation season to the current month, after adjusting with its delivery efficiency. These computations are necessary since the Allocation Curve defined in Figure 5-43 (Available Resource Vs Allocation table) is defined as at the start of the irrigation season.

Once the available water is computed at the start of irrigation season, allocation is computed to be announced for the current month in simulation. During an irrigation season, the allocation can change; generally the allocation increases as the season progresses, since the inflows to storages are greater than those assumed to compute the “announced” allocation.

Irrigation Restrictions

At each simulation time step within the irrigation season, *Limit* for each demand zone under this demand group is computed corresponding to the announced allocation. *Limit* is explained in Section 5.5.2. As stated in Section 5.5.2, in REALM, the limit curve equation (i.e. Equation 5.4) computes the cumulative restricted demand from start of the irrigation season to the end of the current month for the “announced” allocation. The restricted demand for the current month is then computed as the difference between the above cumulative demand and the demand supplied so far during the irrigation (up to the current irrigation season). There may be cases, where there will be large flows in the river in the vicinity of the demand zone, which can be used as off-quota deliveries, which are considered in the annual volume of water entitled to this demand zone in restricting the demand. Therefore, these off quota supplies or deliveries are added to the cumulative restricted demand at this simulation time step to show the total irrigation delivery entitled to this demand zone. These concepts are shown in Figure 5-44 to illustrate how irrigation restrictions are computed in this demand zone.

In Figure 5-44, the (“announced”) allocation is 130% from August to October. During this period, the computed cumulative unrestricted demand is less than the cumulative restricted demand (with respect to 130% “announced” allocation) and therefore the demand is not restricted. Note that 130% announced allocation gives a curve for

cumulative restricted demand with respect to months in the irrigation season. Due to increased water resources available for release, the allocation is increased to 180% in November, and as can be seen from Figure 5-44, it gives a different curve for cumulative restricted demand and also there are no restrictions for November. In December, off quota supplies or deliveries are “announced”; off quota supplies are not considered in determining restrictions. Therefore, to model this effect, the additional curve, which is parallel to the 180% limit curve, is considered as the new limit curve. The gap between these two parallel curves is the off quota supply. Again, as can be seen from Figure 5-44, from February to April, there are some restrictions. For these months, the deliveries from the start of irrigation season to the current month (not inclusive) are subtracted from the cumulative restricted demand computed from) (with respect to 180% “announced” allocation) plus the off quota supplies, as the restricted demand.

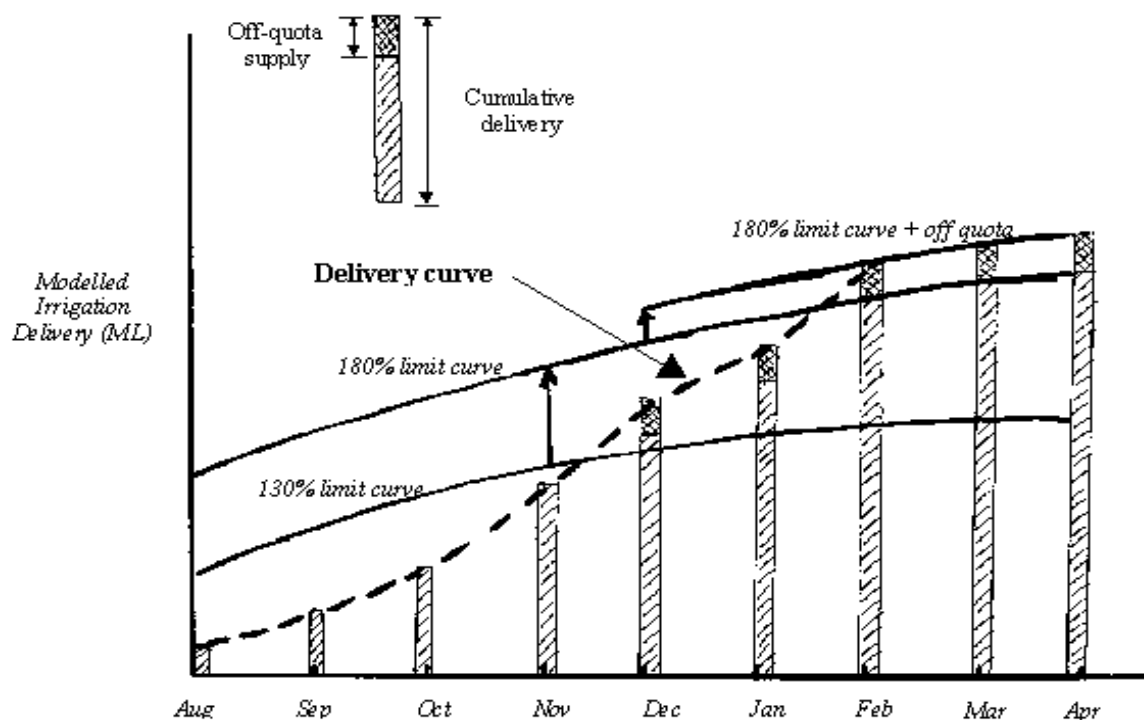


Figure 5-44 Modelling of Off Quota and Changes in Allocation

The unrestricted demand data is usually read from demand data file(s), but the unrestricted demand can also be calculated using a variable capacity carrier or by using the PRIDE demand modelling function in REALM (Section 5.5.2.3) or by linking REALM with an external computer program..

5.7.1.6 IRRIGATION DEMAND RESTRICTIONS BY CARRIER

Click on the radio button ‘Set Policy for this group by Carrier’ in the “Restrictions” dialog box after selecting a demand group which consists only of DC2 nodes, as in of Figure 5-45. Note that this operation displays an additional field with the heading of ‘Name of Carrier’. Enter the Name of Carrier or select the Name of Carrier through the combo box list. This carrier is a variable capacity carrier, which computes the capacity of the carrier as the “announced” allocation for the simulation time step. The user does not need other data for this option.

During simulation, REALM computes the “announced” allocation for the simulation time step using the information given in the variable capacity carrier, which models the restrictions and then uses this allocation in the limit curve equation (i.e. Equation 5.4) to compute the restricted demand, as in Section 5.7.1.5.

The ‘*Planning period begins/ends*’ fields are the same as for the “Allocation Season” block for irrigation demand restrictions by menus (Section 5.7.1.5). The function of the ‘*Allow only positive mid-season allocation changes*’ check box is also explained in Section 5.7.1.5.

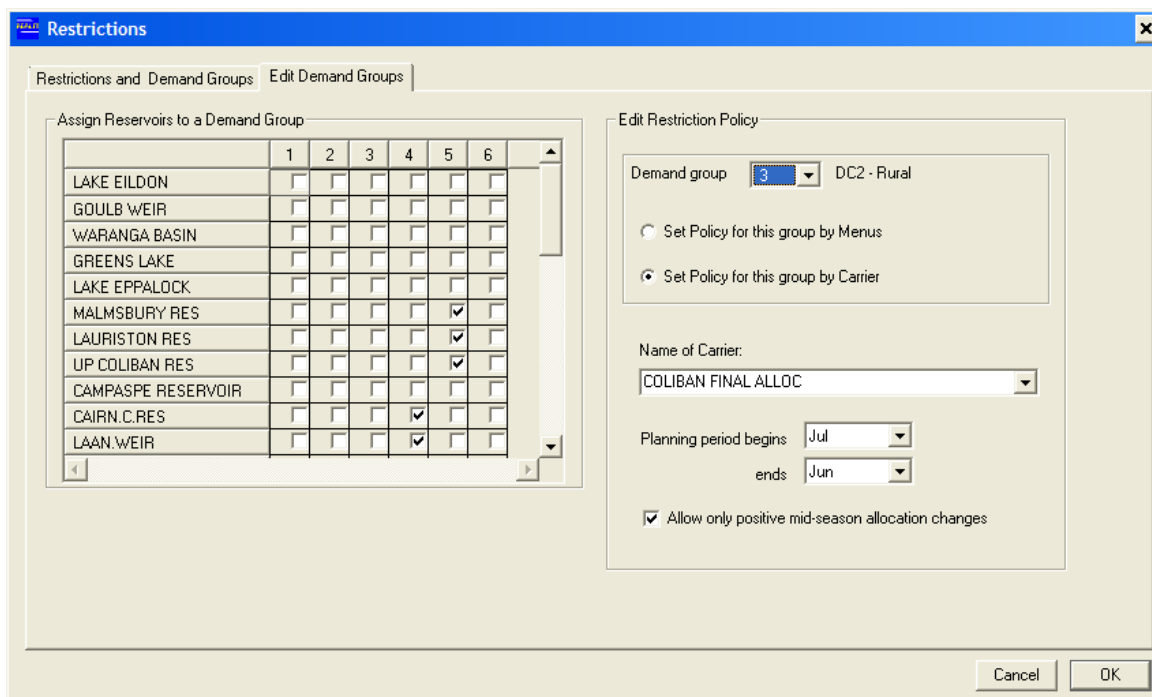


Figure 5-45 Irrigation Demand Restrictions Through a Carrier Setting Dialog Box

5.8 RESERVOIR TARGETS

There are several ways of meeting a given set of demands from a multi-reservoir system. In some cases, it may be appropriate to supply these demands from certain reservoirs in preference to the others. It may also be necessary to force inter-reservoir transfers to distribute water within the water supply system, so as to supply the required demand. These considerations can be modelled using carriers with appropriate carrier penalties. Also they can be modelled using reservoir targets (or more commonly known as target storage curves).

The target storage curves specify the preferred distribution of storage volume among individual reservoirs in a multiple reservoir system. They are defined for the whole range of total system storage giving preferred storage volumes of individual storages. The target storage curves can be one set for all 12 months of the year, one set each for each month or different sets for different seasons. (e.g. one set for summer and another for winter).

Figure 5-46 shows the target storage curves for a two-reservoir example. For a given total system storage S_T at a given season, the target storage curves specify the storage volumes at reservoirs 1 and 2 as S_1^* and S_2^* respectively, where the sum of S_1^* and S_2^*

equals S_T .

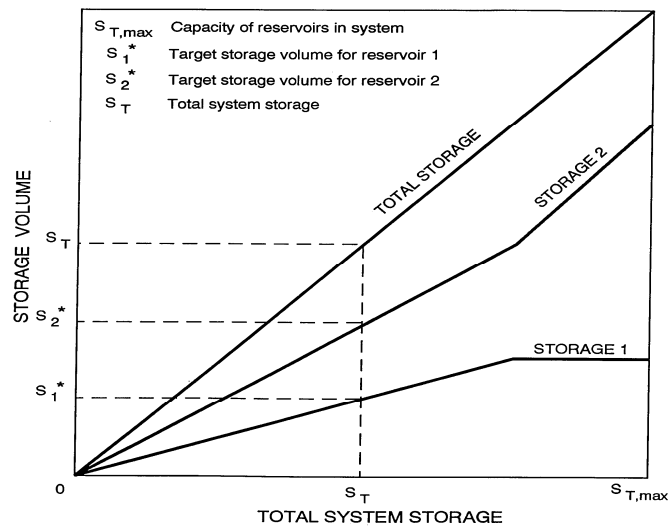



Figure 5-46 Target Storage Curves for a Two-Reservoir System

To set Reservoir Targets:

Click on the *Edit:: Targets* menu item in the System Editor window **or**

Click on the  'Edit Targets' button (Figure 5-1). The "Targets" dialog box is displayed (Figure 5-47). Note that all reservoirs included in the system file are extracted and their names listed as rows under the 'Reservoir Name' column of the "Assign Reservoirs to systems for the target volume calculation" block.

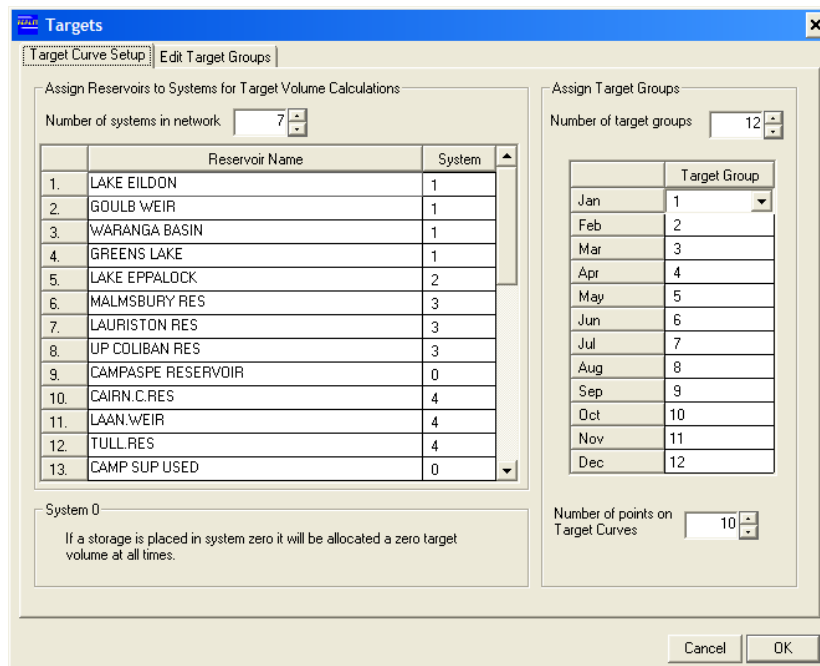


Figure 5-47 Target Curve Setup Tab in Targets Dialog Box

5.8.1 TARGET CURVE SETUP

Experience in combining system networks revealed that the behaviour of the combined system was different to the behaviour of the individual systems simulated separately, even though (in some cases) there are no interconnections between these subsystems. Sometimes it may be necessary to model these subsystems to behave, as they were single subsystems. This can be modelled via the '*Number of systems in network*' in Figure 5-47.

If the user wishes to model the system without reproducing the behaviour of subsystems as previously modelled, then select 1 for all reservoirs shown in the "Assign Reservoirs to Systems for Target Volume Calculations" block of Figure 5-47, having the '*Number of systems in network*' set as 1. Otherwise, select the appropriate number for each reservoir to group under different subsystems. However, make sure that the '*Number of systems in network*' is filled before assigning systems to the reservoirs.

In some cases, the user may not want to include certain reservoirs in target storage calculations (e.g. accounting reservoirs). In this case, these reservoirs can be assigned system zero. If system zero is assigned to a reservoir, this reservoir will have zero target storage volume during the whole simulation. Note that in Figure 5-47, three reservoirs are assigned system zero, and there are 7 systems in the network, excluding system zero.

Target Groups

Fields in the "Assign Target Groups" block allow the number of target groups to be defined and assign target group numbers for each of the months. They do not have to be consecutive. If the user requires only one set of target storage curves for each month of the year, select 1 in each month field. On the other extreme, the user can select 1 to 12 for months to specify different targets for different months. Alternatively, the user can use different targets for different groups of months with different numbers. For example, if the user wishes to use 2 sets of targets, one for summer months (October-March) and the other for winter months (April-September), then select 1 for fields referring to October-March and 2 for the remaining month. Make sure the '*Number of target groups*' field has to be filled before assigning group for months.

Number of points on Target Curves

The user is also required to enter the number of points, which define the target storage curves before editing systems and target groups, through the field '*Number of points on Target Curves*' of Figure 5-47. These points include minimum and maximum storage capacities. In Figure 5-47, there are 7 systems and 12 target groups, meaning there will be 84 target storage curves to be edited. Also the '*Number of points on Target Curves*' has been set to 10, which means that 10 points (including minimum and maximum capacities) are used to define all target storage curves of different systems and target groups.

5.8.2 TARGET STORAGE FOR EACH GROUP & EACH MONTH

The required target group of the system can be edited by selecting the "Edit Target Groups" tab from the "Targets" dialog box (Figure 5-47). This will display Figure 5-48, which allows the user to edit the target storage curves for a specific system and target group.

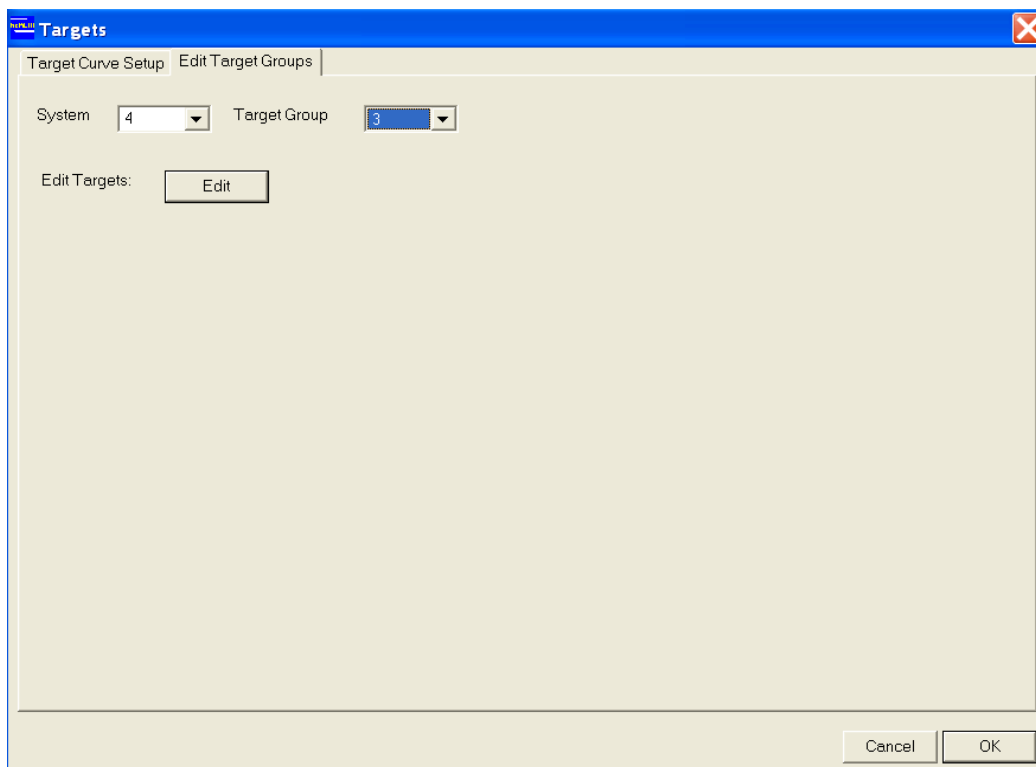


Figure 5-48 Specification of System and Target Group for Editing Target Storage Curves

Select the system number and the group number as in Figure 5-48, and click on the **Edit** button. This will display Figure 5-49, which allows the user to edit the target storage curve information and the drawdown priorities for reservoirs. Note that the dialog box in Figure 5-49 allows the user to edit the target storage curves for system 4 and target group 3, which has been selected in Figure 5-48. Also the target storage curves are defined by 10 points, as selected in Figure 5-47. The user is not able to edit minimum and maximum capacities and they are greyed out. Note also that all reservoirs included in the system (Figure 5-47) are extracted and their names listed as rows in Figure 5-49. In the background, there is a plot of the target storage curves for this system and target group.

The reservoir drawdown priorities specify the order in which the reservoirs are drawn down when they go below their target volumes during (simulation) run time. When this happens, the reservoir with the lowest drawdown priority will be emptied first, followed by the reservoir with the next lowest drawdown priority and so on. Only the reservoirs which will go below target, are considered in this case. In some cases, certain reservoirs may go above target. In this case, the drawdown priorities are used in the reverse order. The reservoir with the highest drawdown priority will be recharged first, followed by the reservoir with the next highest priority and so on. Only the reservoirs, which will go above targets, are considered in this case. Reservoirs going above and below targets are modelled through 'Number of Above/Below Target Zones'. More details can be found in Section 5.4.4.2.

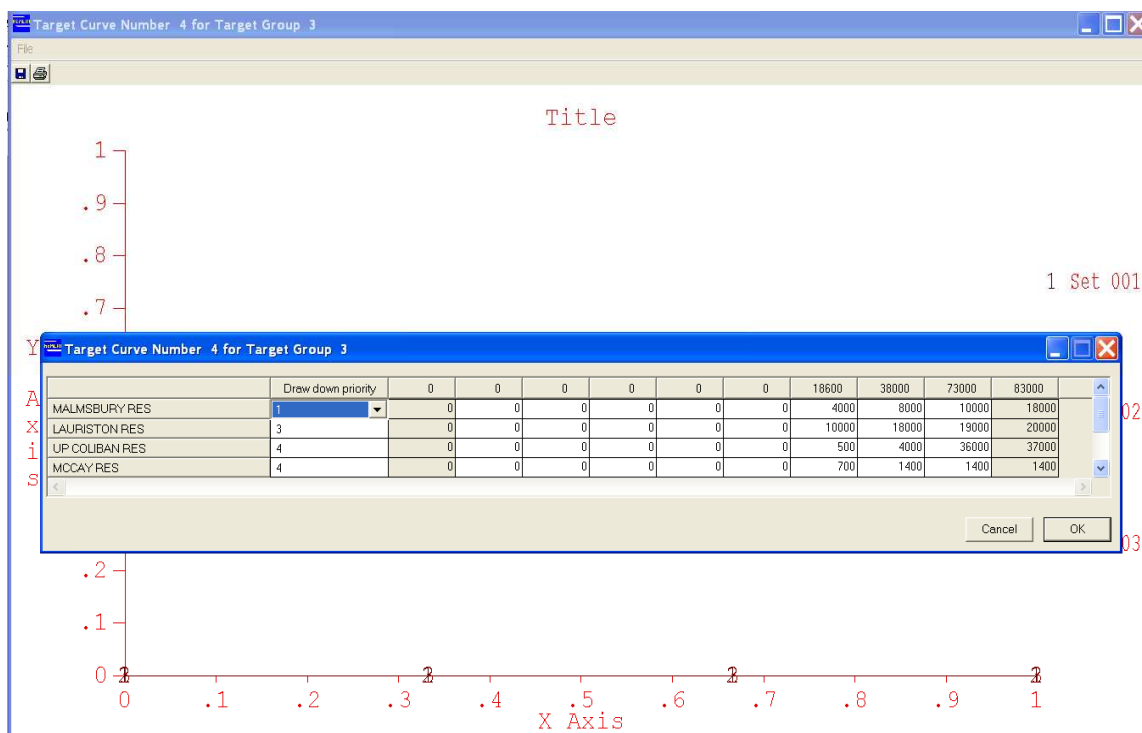



Figure 5-49 Editing Target Storage Curves for a System and a Target Group

Enter the drawdown priorities for reservoirs and the preferred storage volumes of the reservoirs in the system in Figure 5-39. In defining the target storage curves, the storage volume of individual reservoirs should be non-decreasing, when values are entered in the fields from left to right.

If more than one system and one target group is specified in Figure 5-47, the corresponding reservoir target storage curves and drawdown priority should be provided for each system and each target group.

5.9 LABEL

The system file label describing the system can be included or edited using the  'Edit the system file label' button on the toolbar (Figure 5-1). Alternatively the user can use *Edit::System Label* menu item to display the same dialog box. When this button is clicked the "System File Label" dialog box (Figure 5-50) appears, which allows the user to enter or edit the file description.

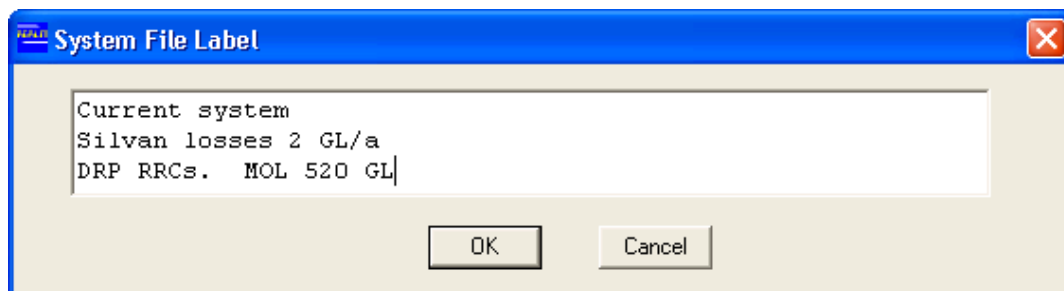



Figure 5-50 System File Label Dialog Box

5.10 EXIT

To exit from SE hence to return to REALM Program Manager either use *File::Exit* menu item or


Click on the  'Exit System Editor' button or


Click on the  'Close' button in the top right corner of the System Editor window.

If the current system file has been changed since the last save, then a message box will appear prompting the user to confirm whether to save the changes to the file. Click on **Yes** to save the changes or **No** to exit the System Editor with saving changes.

By clicking on **Cancel** button, the user can return to SE without exiting.

5.11 SYSTEM LISTING PROGRAM

The system files created by System Editor (SE) are text (or ASCII) files. However, the user may not be able to interpret the data in these file, since there are no captions attached to these data items. The REALM System Listing program reads the data from the system file and creates a file called *system_temp.lis*, with captions on data items. This file is generally called the "System Listing". By using a standard text editor such as Notepad in Windows, the user can easily interpret the data in the system file that has been created. Alternatively the user can use the REALM Text Editor facility by clicking on  'View Text File' button (Section 4.4.3) of the REALM Program Manager (Figure 4-1).

Select the System Listing program through *System::Listing* from the REALM Program Manager (Figure 4-1). The "System Listing" dialog box (Figure 5-51) is displayed. Enter the name of the system file in the first field or click on the  button to browse and select a file. Tick the required information categories which should appear in the output file, and click on the **OK** button to create the output file.

Then the "View Output File" dialog box will be displayed. Click on **Yes** to open the file in the REALM Text Editor. The file may be viewed and printed from any standard text editor program, such as Notepad in Windows.

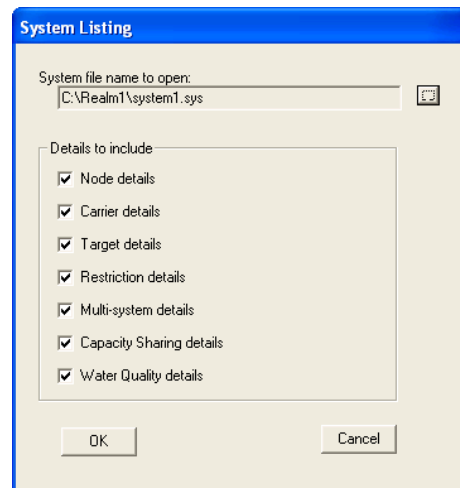


Figure 5-51 System Listing Dialog Box

The system listing is organised in the following fashion:

- General node details: number, name, location and size
- Additional parameters for each node type (reservoirs, demands etc.)
- General carrier details: number, name, from and to node, offset and loss factor
- Minimum and maximum capacities of carriers (including equations to calculate capacities)
- Reservoir targets
- Restriction policies
- Multi-system parameters
- Water quality details

The file *system_temp.lis* is overwritten each time the REALM System Listing program is used. A typical system listing is shown in Figure 5-53 for a sample system file with the sample network as shown in Figure 5-52. The user is referred to REALM Worked Examples Manual (Victoria University and Department of Sustainability and Environment, 2005) for system listings of several worked examples.

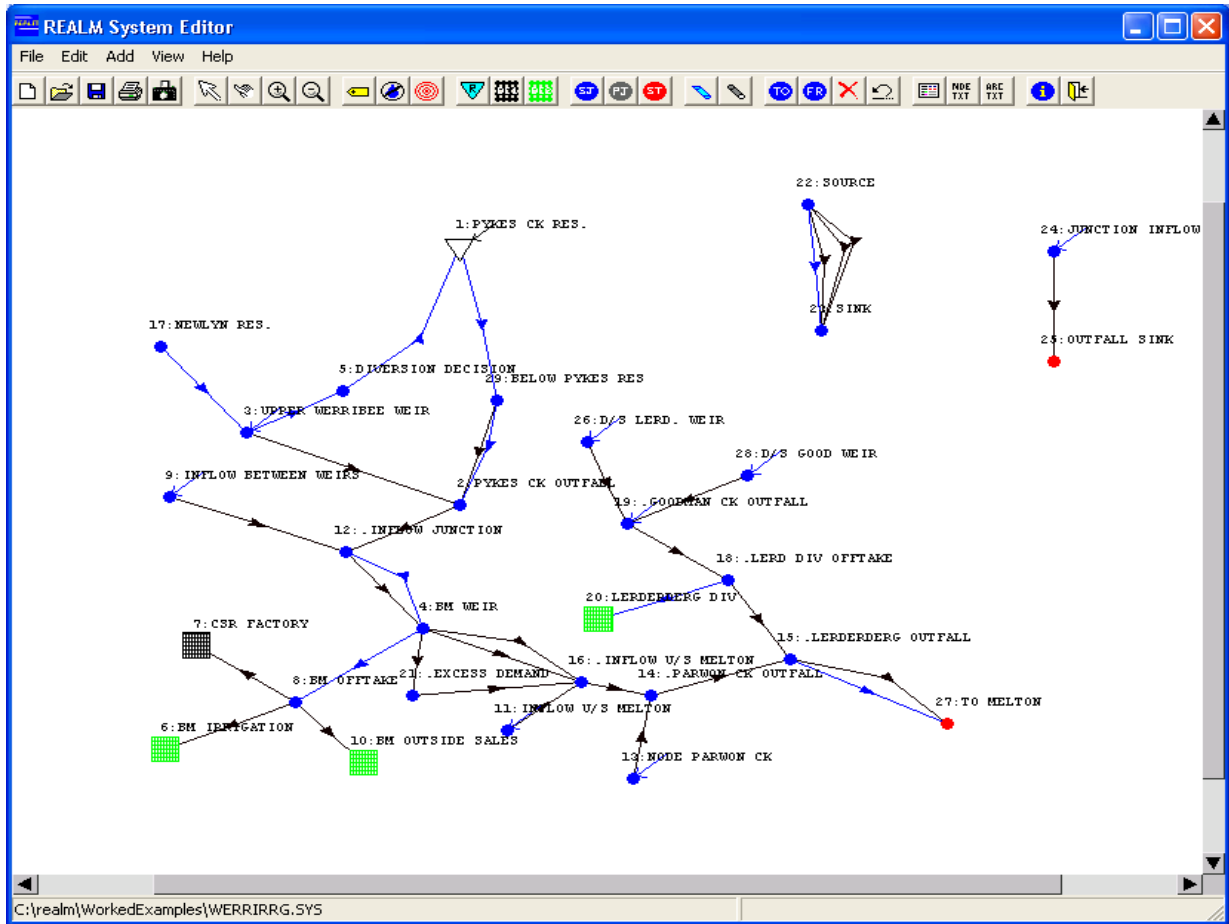


Figure 5-52 Example Network used to Generate System Listing

```

R      E      A      L      M

*****
*   SYSTEM FILE LISTING   *
*****

File: C:\realm\WorkedExamples\WERRIRRG.SYS

Simulation label:
  Werribee System: WERR0001.sys; As in WERRK317.SYS but with
  system truncated to Werribee R. u/s of Pyrites ck.

Date: 21:51   12/10/2005

-----
|  NODE INFORMATION  |
-----

-----
No      Name      Type      X      Y      Z      Size  Aux Input  No
-----
1  PYKES CK RES.      Reservoir      5.18  10.52  0.00  1.00  PYKES CK INFLOWS  1
  Comment: Pykes Creek Reservoir
2  PYKES CK OUTFALL  Strm junction  4.82   7.10  0.00  1.00  2
  Comment: Pykes Creek junction with Werribee River
3  UPPER WERRIBEE WEIR Strm junction  2.76   8.23  0.00  1.00  WERRIBEE @ BALLAN  3
  Comment: Upper Werribee Weir.
4  BM WEIR           Strm junction  4.45   5.19  0.00  1.00  4
  Comment: Bacchus Marsh Weir on the Werribee R.
5  DIVERSION DECISION Strm junction  3.68   8.88  0.00  1.00  5
  Comment: Pykes tunnel. Second condition for flow.
6  BM IRRIGATION     Irr Demand     1.96   3.30  0.00  1.00  B 6
  Comment: BM irrigation supply
7  CSR FACTORY       Demand         2.27   4.92  0.00  1.00  7
  Comment: CSR factory supply.
8  BM OFFTAKE        Strm junction  3.23   4.03  0.00  1.00  8
  Comment: Offtake to supply irrigation area demand& other demand supplied from channels.
9  INFLOW BETWEEN WEIRS Strm junction  2.00   7.23  0.00  1.00  INFLOW BET.N WEIRS  9
  Comment: Inflow between weirs.
10 BM OUTSIDE SALES  Irr Demand     3.88   3.09  0.00  1.00  B 10
  Comment: BM outside sales. Excess returns to Werribee River.
11 INFLOW U/S MELTON Strm junction  5.27   3.60  0.00  1.00  INFLOW BM TO MELTON 11
  Comment: General inflow upstream Melton Res.
12 .INFLOW JUNCTION  Strm junction  3.72   6.37  0.00  1.00  12
  Comment: Inflow junction @ Werribee R. upstream Melton Res.
13 NODE PARWON CK    Strm junction  6.49   2.85  0.00  1.00  PARWON CK 13
  Comment: Parwon Creek.
14 .PARWON CK OUTFALL Strm junction  6.66   4.14  0.00  1.00  14
  Comment: Parwon Creek outfall to Werribee River.
15 .LERDERBERG OUTFALL Strm junction  8.01   4.70  0.00  1.00  15
  Comment: Lerderderg River to Werribee River.
16 .INFLOW U/S MELTON Strm junction  5.98   4.35  0.00  1.00  16
17 NEWLYN RES.      Strm junction  1.92   9.57  0.00  1.00  17
  
```


No	Name	Type	From	To	Cost	Offset	Loss	Ann Vol	Shr	Gp	Shr%	No
1	PYKES DIV1	Pipe	3	5	10	0	0fix		0		0%	1
	Comment: Diversions to Pykes Res from Werribee River.											
2	PYKES DIV2	Pipe	5	1	10	0	0fix		0		0%	2
	Comment: Pykes tunnel diversion 2 from Werribee River.											
3	UPPER WEIR OVERFLOW	River	3	2	100	0	0fix		0		0%	3
	Comment: Spill over upper Werribee Weir.											
4	PYKES CK SPILL	River	29	2	10	0	0fix		0		0%	4
	Comment: Pykes Ck spills below Reservoir.											
5	WERRIBEE D/S PYKES	River	2	12	10	0	1%		0		0%	5
	Comment: Werribee River downstream of Pykes Ck junction.											
6	TO BM IRRIGATION	River	8	6	10	0	15%		0		0%	6
	Comment: Supply channel to BM irrigation area											
7	TO CSR FACTORY	River	8	7	10	0	15%		0		0%	7
	Comment: Supply channel to CSR factory											
8	BM-OFFTAKE	Pipe	4	8	10	0	0fix		0		0%	8
	Comment: Irrigation offtake from above BM weir.											
9	WERRIBEE U/S BM WEIR	River	12	4	10	0	1%		0		0%	9
	Comment: Werribee River upstream Bacchus Marsh weir. Min. operational flow 5 ML/d											
10	FROM INFL BTWN WEIRS	River	9	12	10	0	0fix		0		0%	10
	Comment: Inflows between weirs to the werribee river.											
11	TO BM OUTSIDE SALES	River	8	10	10	0	15%		0		0%	11
	Comment: Bacchus Marsh outside district sales of irrigation water.											
12	WERRIBEE D/S BM	River	4	16	10	0	0fix		0		0%	12
	Comment: Werribee downstream of BM weir & u/s of 'Above Melton' inflow.											
13	WERRIBEE U/S PARWON	River	16	14	10	0	0fix		0		0%	13
	Comment: Werribee River upstream of Parwon Creek											
14	WERRIBEE U/S LERD	River	14	15	10	0	0fix		0		0%	14
	Comment: Werribee River upstream of Lerderderg River junction.											
15	FROM INFL U/S MELTON	River	11	16	10	0	0fix		0		0%	15
	Comment: Inflow upstream Melton											
16	FROM PARWON CK	River	13	14	10	0	0fix		0		0%	16
	Comment: Parwon Creek											
17	LERD D/S GOOD.	River	19	18	10	0	0fix		0		0%	17
	Comment: Lerderderg River below Goodman's Creek junction. Min. 80 ML/d (Aug-Oct)											
18	LOWER LERD	River	18	15	10	0	0fix		0		0%	18
	Comment: Lerderderg River d/s of Goodman Ck. conf to confl. Werr R. Section Environ flows											
19	UPPER DIVERSIONS	Pipe	18	20	10	0	0fix		0		0%	19
	Comment: Diversions off Lerderderg River.											
20	NEWLYN SUPPLY	Pipe	17	3	10	0	0fix		0		0%	20
	Comment: Goodman's diversion tunnel											
21	PYKES CK REL	Pipe	29	2	50	1	4%		0		0%	21
	Comment: Pykes Creek releases.											

22	BM OPER SPILL	River	4	21	-5000000	0	0	Ofix	0	0%	22		
23	LIMIT OPER SPILL	River	21	16	-10	0	0	Ofix	0	0%	23		
24	EXCESS RELIEF	River	24	25	10	0	0	Ofix	0	0%	24		
25	ENV SECTION 1	River	22	23	-1	4	0	Ofix	0	0%	25		
Comment: SECTION 1 - Recommended Env. min. flows d/s LERDERDERG WEIR													
26	SPILLS+MIN ENV FLOWS	River	26	19	1	0	0	Ofix	0	0%	26		
Comment: Carrier to tranship spills & min. env. flows													
27	ENV SECTION 2	River	22	23	1	-1	0	Ofix	0	0%	27		
Comment: Recommended env. min. flow d/s Lerderderweir - Section 2.													
28	ENV FLOW 2 ML/D	River	22	23	0	-3	0	Ofix	0	0%	28		
Comment: Env. flow of 2 ML/d													
29	#1 D/S BM WEIR ENV	River	4	16	-5000000	-2	0	Ofix	0	0%	29		
Comment: Werr R. d/s BM weir & u/s of 'Above Meltinflows; Env. flow = 12 ML/d													
30	NAT FLOW U/S BM	Pipe	22	23	1	0	0	Ofix	0	0%	30		
Comment: Sum of natural inflows u/s of BM weir													
31	GOODMANS D/S WEIR	River	28	19	10	0	0	Ofix	0	0%	31		
32	ENV D/S PYKES CK	Pipe	12	4	-50000000	2	0	Ofix	0	0%	32		
Comment: Minimum env. flow in Werrabee R. d/s Pykes Ck. (forces thro' high -ve penalty													
33	WERRIBEE U/S PYRITES	River	15	27	-50000000	-2	0	Ofix	0	0%	33		
34	EXCESS FLOW	Pipe	15	27	100	0	0	Ofix	0	0%	34		
Comment: Discharge excess													
35	RELEASES FROM PYKES	Pipe	1	29	0	0	0	Ofix	0	0%	35		
Comment: to model the dead storage explicitly													

Minimum Flows													
No	Name	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17	LERD D/S GOOD.	0	0	0	0	0	0	0	2480	2400	2480	0	0
18	LOWER LERD	1178	1074	1178	1140	1178	1140	1178	3100	3000	3100	1800	1178
25	ENV SECTION 1	930	848	930	900	930	900	1550	1550	1500	1550	1500	930
27	ENV SECTION 2	1178	1074	1178	1140	1178	1140	1178	3100	3000	3100	1800	1178

Maximum Flows													
No	Name	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	UPPER WEIR OVERFLOW	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
4	PYKES CK SPILL	0	0	0	0	0	0	0	0	0	0	0	0
5	WERRIBEE D/S PYKES	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
6	TO BM IRRIGATION	3255	3045	3255	3150	3255	3150	3255	3255	3150	3255	3150	3255
7	TO CSR FACTORY	3255	3040	3255	3150	3255	3150	3255	3150	3150	3255	3150	3255
8	BM-OFFTAKE	3255	3045	3255	3150	3255	3150	3255	3255	3150	3255	3150	3255
9	WERRIBEE U/S BM WEIR	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
10	FROM INFL BTWN WEIRS	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
11	TO BM OUTSIDE SALES	3255	3045	3255	3150	3255	3150	3255	3255	3150	3255	3150	3255
12	WERRIBEE D/S BM	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
13	WERRIBEE U/S PARWON	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
14	WERRIBEE U/S LERD	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
15	FROM INFL U/S MELTON	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
16	FROM PARWON CK	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
17	LERD D/S GOOD.	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
18	LOWER LERD	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
19	UPPER DIVERSIONS	200	200	200	200	200	200	200	200	200	200	200	200
20	NEWLYN SUPPLY	820	820	820	820	820	820	820	820	820	820	820	820
21	PYKES CK REL	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
23	LIMIT OPER SPILL	200	200	200	0	0	0	0	500	500	500	500	200
24	EXCESS RELIEF	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999
25	ENV SECTION 1	930	848	930	900	930	900	1550	1550	1500	1550	1500	930


```

' 2 = 1190                                Type: NUMB
Previous flow solution is added to new capacity
Capacity set option (0-off 1-prev 2-recalc) Jan=2 Feb=2 Mar=2 Apl=2 May=2 Jun=2 Jul=2 Aug=2 Sep=2 Oct=2 Nov=2 Dec=2
-----
| TARGET INFORMATION |
-----

Number of target sets: 1

-----
Target set 1 ( Jan Feb Mar Apl May Jun Jul Aug Sep Oct Nov Dec)
Name          Draw Pri          Targets
-----
PYKES CK RES.      1      1190      3716      6241      8767      11292      13818      16343      18869      21394      23920
totals              1190      3716      6241      8767      11292      13818      16343      18869      21394      23920
-----
| RESTRICTION INFORMATION |
-----

Number of restriction groups: 1

NB. Each restriction group is treated separately
with its own rule curve definitions for urban demand groups;
for irrigation demand groups by its allocations functions.

-----
Restriction Group: 1      Type: Irrigation demand centers
-----

Reservoirs/          Demands
carriers in Group    in Group
-----
PYKES CK RES.        BM IRRIGATION
                    BM OUTSIDE SALES

Allocation period from 8 to 4
Only +ve midseasonal changes in allocation allowed
The unrestricted allocation reference is      220
The average efficiency of deliveries from Headworks to the farm gate is assumed to be 72% for seasonal allocation purposes.

1 year planning period of 1 planning periods to be considered.
The group reserve (additional to common reserve) is      0
The trigger for special accounting is      0
The trigger for group reserve reduction is      0

Factor
No      Jan      Feb      Mar      Apl      May      Jun      Jul      Aug      Sep      Oct      Nov      Dec
1        0        41       0        21       0        0        0        105     420     400     125     21
2        0        0        0        0        0        0        0        0        0        0        0        0
3        0        0        0        0        0        0        0        0        0        0        0        0
4        0        0        0        0        0        0        0        0        0        0        0        0

Allocation function: pt1      pt2      pt3      pt4      pt5      pt6      pt7      pt8      pt9      pt10     pt11     pt12
                    938      8047     8905     9576     9798     10671    11310    12181    12763    15740    16816    99999999
                    0        100      110      120      130      150      160      180      200      220      220      220

```

```
-----  
| MULTI SYSTEM INFORMATION |  
-----  
  
Reservoirs  
-----  
PYKES CK RES.      1  
  
-----  
| CAPACITY SHARING INFORMATION |  
-----  
  
(a negative represents capacity key for group)
```

Figure 5-53 Typical System Listing

Chapter 6

6 SETUP (S)

The REALM Setup (S) sets up the run time parameters for REALM simulation. The run time parameters are specific to a particular REALM simulation run and include information such as simulation period, input files to be used, initial reservoir volumes and output options. The run time parameters for a particular run are called a scenario and this information can be stored in a scenario file. At the end of REALM Setup, these run time parameters are saved in a file called *ans_file.dat*.

The following REALM input files are required to run S:

- streamflow file(s)
- demand file(s)
- system file(s)
- initialisation files (in some cases).

6.1 GETTING STARTED

To access REALM Setup, click on the *Run::Setup* menu item of the REALM Program Manager (Figure 6-1) or

Click on the  'Run REALM setup' button on the toolbar.



Figure 6-1 Run Menu Listing with Setup Selected

The background window will change from REALM Program Manager (Figure 4-1) to REALM Setup.

The “Scenario file selection” dialog box will be displayed (Figure 6-2).

6.2 SCENARIO FILES

If the project directory does not contain any scenario files, then the ‘Use scenario file’ field will be blank.

If there are already Scenario files in the current project directory, then the Scenario file selection dialog box will appear as in Figure 6-2, giving the user the option to select an existing file or create a new file.

6.2.1 NULL SCENARIO

Click on the **Null Scenario** button to create a new scenario file for the simulation.

Even if there are scenario files present in the project directory, the user may create a new scenario file from scratch using the **Null Scenario** button.

Clicking on the **Null Scenario** button closes the “Scenario file selection” dialog box (Figure 6-2).

The REALM Setup window (Figure 6-3) is displayed to start working. Note the labels on the status bar. The left label indicates the project directory, in this case `C:\REALM\GetStart`. The scenario file is left blank, since the user is creating a new scenario.

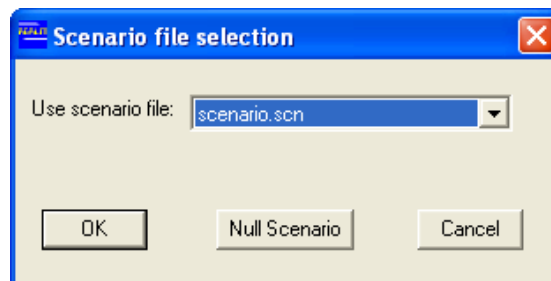


Figure 6-2 Scenario File Selection Dialog Box with Existing Files

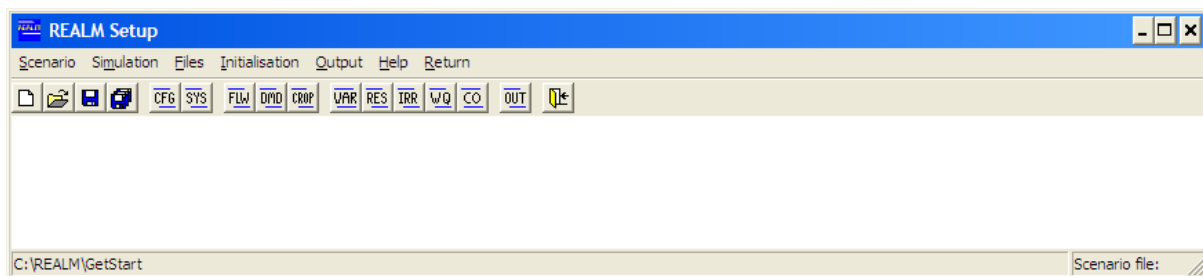


Figure 6-3 Setup Window

6.2.2 EDITING AN EXISTING SCENARIO

To edit an existing scenario select the scenario file from the ‘Use scenario file’ list of Figure 6-2 and click **OK**.

Note that the ‘System file’ of the status bar changes to ‘Scenario file’ and the field next to ‘Scenario file’ contains the scenario filename just selected. The **Cancel** button in Figure 6-2 takes the user back to REALM Program Manager (Figure 4-1).

Whether creating or editing a scenario file, the operations are similar. When creating a scenario file, there is no information in the REALM Setup windows, whereas when editing, the information of the selected scenario is available. The REALM Setup window (Figure 6-3) is similar in both cases, except that the right label of the status bar is blank for a new scenario, whereas it contains the scenario filename to be edited when editing a scenario.

6.2.3 SCENARIO FILE OPERATIONS

The Scenario menu item contains two partitions as follows.

- Open
- New

- Save
- Save As




Figure 6-4 Scenario Menu

6.2.3.1 OPEN

To open an existing Scenario file:

Click on the *Scenario::Open* menu item or

Click on the  'Open existing scenario' button.

If the scenario files are available in the project directory, then the "Specify scenario file" dialog box is displayed with a list of the scenario files available. (If there are no scenario files in the project directory, the error message "No scenario files in directory" will be displayed.)

Select the required scenario file from the list in the 'Filename' drop down box.

Click on **OK** to open the scenario file and to display the REALM Setup window (Figure 6-3).

The **Cancel** button takes the user back to the REALM Setup window (Figure 6-3), without opening a scenario file.

6.2.3.2 NEW

To create a new Scenario file:

Click on the *Scenario::New* menu item or

Click on the  'Create new scenario' button.

This displays a dialog box to specify the new scenario filename (Figure 6-5).

Enter the new scenario filename.

Click **OK** to create a new scenario by this name and return to the REALM Setup window.

The **Cancel** button takes the user back to the REALM Setup window (Figure 6-3), without creating a new scenario file.



Figure 6-5 Create a New Scenario Dialog Box

6.2.3.3 SAVE AND SAVE AS

To Save As:

Save As is used to name and save a newly created scenario file, or to save an existing scenario under a different filename.

Click on the *Scenario::Save As* menu item menu item **or**

Click on the  'Save scenario as new name' button.

Enter a descriptive filename.

Click **OK**.

The **Cancel** button takes the user back to the REALM Setup window (Figure 6-3) without saving.

To Save:

For an existing file, click on the *Scenario::Save* menu item **or**


Click on the  'Save scenario' button.

Note that REALM prompts the user to enter a filename if the user attempts to save an unnamed scenario. The **Cancel** button takes the user back to the REALM Setup window (Figure 6-3) without saving.

Once the scenario file is saved or if the user is editing an existing scenario file, then this operation saves the scenario file under the current name without displaying further windows.

6.3 SIMULATION CONFIGURATION AND SYSTEM FILES

6.3.1 SIMULATION CONFIGURATION

Before running the REALM simulation, it is necessary to configure various requirements and to setup summary output file specifications (i.e. log file). This is done through *Simulation::Run Configuration* menu item or  'Specify log file and run details' button of the REALM Setup window (Figure 6-3). This displays the "Simulation Specification" dialog box, as shown in Figure 6-6.

Simulation log file

The name of the file, to which the log information is written, is entered here. An example is *Tut1.log*, as shown in Figure 6-6. The first four letters of the name given here appear as the first four letters of the names of the REALM format output files. These output files are described in Section 1.1.1.

The log file can be selected from the list of available log files if there are any in the project directory. If an available log file is selected, the existing output files under the specified log filename will be overwritten during the REALM simulation.

Simulation description

In order to allow easy identification of the output files at a later stage, it is advisable to enter a meaningful description here. This field cannot be left blank. If it is left blank, a warning message stating "At least one label must be specified" appears.

Number of replicates

The number of streamflow replicates is entered here. The number of replicates can be stepped up or down through the arrow buttons next to its field. It should not be zero. If it is set to zero, a warning message is displayed, allowing the user to specify the appropriate number of replicates. For most REALM applications, a single streamflow replicate is used.

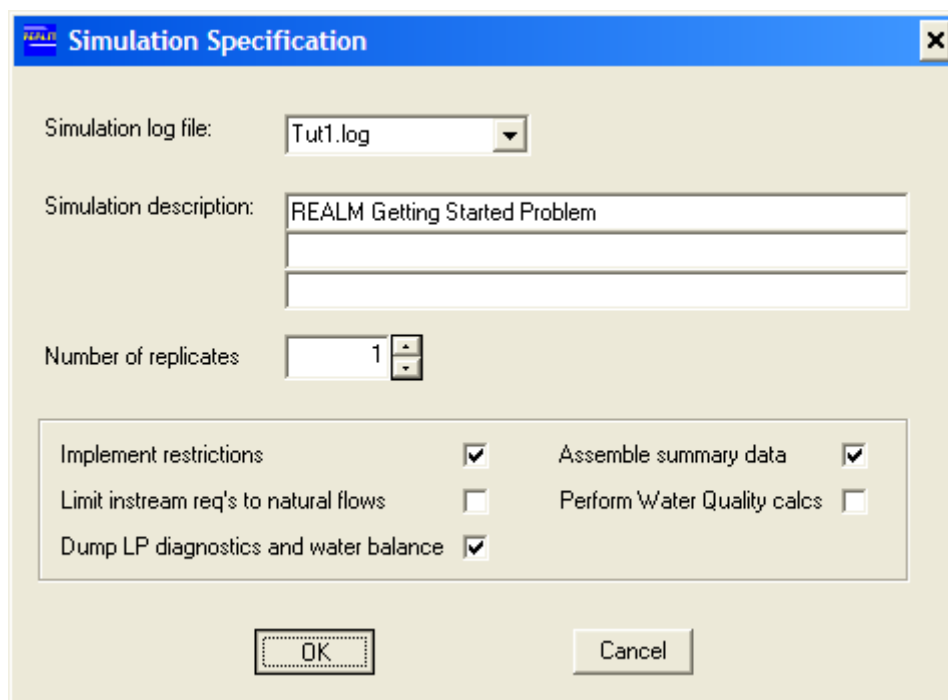


Figure 6-6 Simulation Specification Dialog Box

Implement restrictions

The demand restrictions can be turned on or off by clicking on this field. In Figure 6-6, the restrictions are on for this scenario.

Assemble summary data

If this field is ticked, the summary results of the REALM run will be given in the log file under the headings of nodes and carriers with the run time parameters used in the setup. Otherwise, the summary details are not given in the log file, but the run

time parameters used in the setup will be given in the log file.

Limit instream requirements to natural flows

Sometimes it is necessary to limit the minimum flows in the carriers (i.e. instream flow requirements) to natural flows. This can be done by clicking on this field. If left blank, the full minimum flow requirements of the carriers are met, if necessary through reservoir releases.

Perform water quality calculations

When this check box is ticked, REALM performs water quality calculations. There is about 20–30% increase in computer execution time associated with water quality calculations. Therefore, this flag may be helpful in some cases to reduce the computer execution time, provided that the water quality results are not required for a particular simulation. However, turning off water quality calculations is not possible when the capacities of the variable capacity carriers depend on water quality variables. In such situations, the REALM simulation (when running R - Chapter 7) is aborted showing an error message.

Dump LP diagnostics and water balance:

Ticking this check box enables two separate, but related REALM functions to be performed for a given time step:

- Dump of LP diagnostics;
- Water balance.

Dump of LP diagnostics

REALM uses Network Linear Programming (LP) to solve the flows in the network of nodes and carriers/arcs during a simulation time step. In some cases, the user may want to analyse the solution from LP for a particular time step and a streamflow replicate (in case of multiple replicate runs). When the 'Dump LP diagnostics and water balance' check box is ticked, details of nodes and carriers (including Equivalent Component Network – ECN nodes and arcs) are written to the log file, which can be used for debugging a solution. Section 8.8 details how to interpret an LP dump. (The model run continues after dumping the LP solution for the time step of interest.)

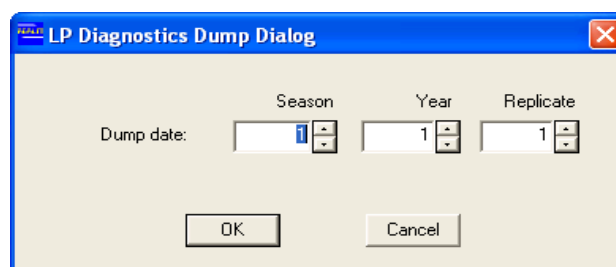


Figure 6-7 LP Diagnostics Dump Dialog Box

Water balance

The user may also be interested in the water balance for a particular time step. Note that the dump of LP diagnostics for the specified time step is written to the log file, but REALM writes the water balance log for that time step to a separate file in the

working directory called [log filename]_waterBalance.txt. The water balance log file can be opened in the Text Editor/File Viewer. The water balance log file contains the following for the time step of interest:

- Start and end storage volume for each reservoir node and for the total system, and change in total storage volume
- Total inflows to stream junctions
- Inflows, net-evaporation and spills for each reservoir node, and for the total system
- Supply to demands and outflows (including losses in carriers)
- Total water balance error and water balance error as a percentage of total inflow.

To Dump LP diagnostics and water balance:

In Figure 6-6, click on the 'Dump LP diagnostics and water balance' (and any other required check boxes) and hit OK. The "LP Diagnostics Dump Dialog" box is displayed then (Figure 6-7). Enter the season, year and replicate for which an LP dump and water balance is requested. The season can be a day, a week or a month (entered as a numeric value, which is discussed in Section 6.3.2).

After entering the required information in Figure 6-7, clicking on the **OK** button takes the user back to the REALM Setup window (Figure 6-3). Clicking on the **Cancel** button takes the user back to Figure 6-6, without saving entered information in Figure 6-7.

6.3.2 SYSTEM FILES

It is necessary to specify the REALM system file(s) that will be used for the REALM simulation.

To specify the simulation period:

Click on the *Simulation::System specification* menu item **or**

Click on the **SYS** 'Specify system files and dates' button of the REALM Setup window (Figure 6-3).

This displays the "System File Dialog" box (Figure 6-8).

Specify the simulation period from *Start Date* to *End Date* by entering numeric values in the 'Season' and 'Year' fields. The 'Season' may be in days, weeks or months. For a simulation with a monthly simulation time step, if the run is to be started from January 1990, the *Season* is indicated by 1, whereas the *Year* is indicated by 1990. In a daily model, if the simulation is to be started from 15 March 1990, the *Season* is entered as 76.

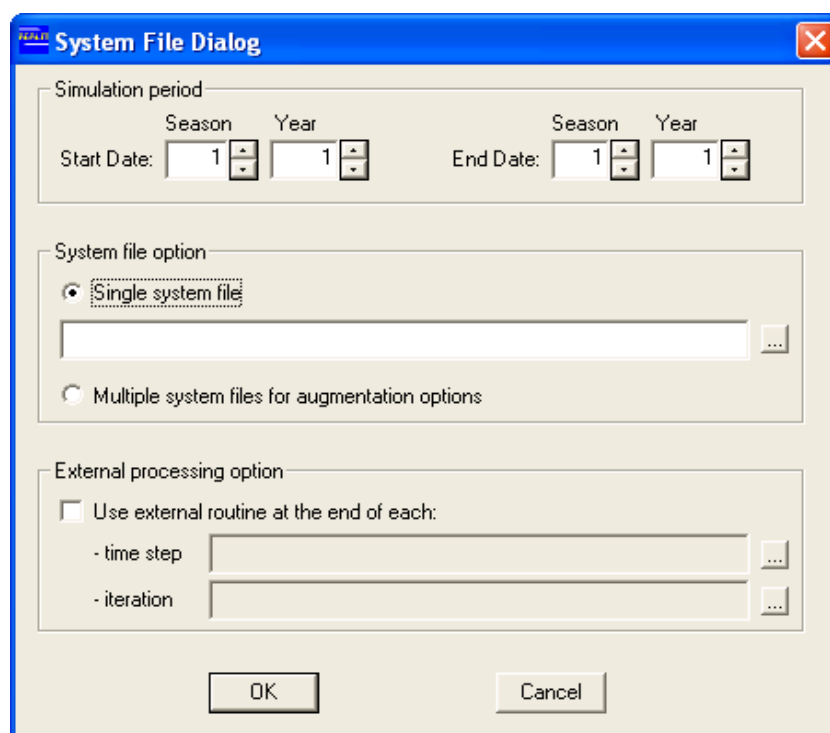


Figure 6-8 System File Specification

To specify the system file(s):

In most REALM simulations, only one system file is used. However, there are cases where it is necessary to use several system files at different times of the simulation period. Multiple system files can be used to simulate the system behaviour with new augmentations and/or system changes (including changes to operating rules). For multiple system file runs, REALM accesses each system file at the time specified during simulation. Matching the reservoir names in various system files allows the storage volumes of reservoirs of a system file to be carried over to the reservoirs in the next system file. Similarly, the carrier names are matched so that carriers can be investigated across several system changes.

If a single system file is to be used, click on the 'Single system file' radio button.

Enter the system filename with the appropriate path **or**

Use the browser button next to the 'Single system file' field to locate the required system file. Click on the required system file and hit **Open**.

Click on **OK**, and return to the REALM Setup window (Figure 6-3).

If multiple system files are to be used click on the 'Multiple system files for augmentation options' radio button.

Click on **OK**. The "Multiple system file selection" dialog box will be displayed. (Figure 6-9).

Enter *Start Season* and *Start Year* for the first system file.

Click on the first row in the *Filename* column, and enter the system filename with the

appropriate path **or**

Use the **Browse...** button to locate the first system file. Click on the required system file and hit **Open**.

Fill in similar information for the other system files.

For example, in Figure 6-9, the system file *C:\Realm1\Ex2e.sys* is used from January 1990 (assuming a monthly time step for the run) and then *C:\Realm1\EX3D.SYS* from January 1995.

Click on **OK**, and return to the REALM Setup window (Figure 6-3).

The **Cancel** button takes the user back to the REALM Setup window, without saving the entered information.

To include external processing:

The 'External processing option' links REALM with external executables. It is an advanced function that requires coding in programming languages such as FORTRAN, and is not detailed in this User Manual.

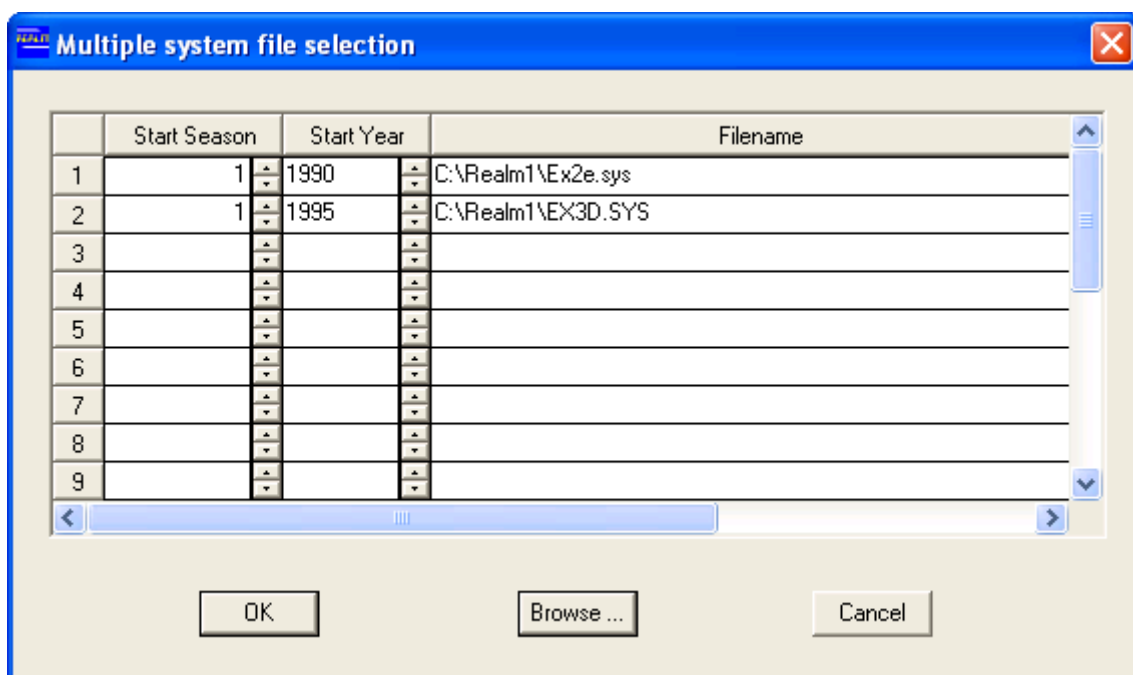


Figure 6-9 Multiple System File Selection

6.4 DATA FILES


Similar to system files, it is necessary to specify streamflow and demand file(s), as well as any crop model data files, that are to be used in a simulation.

6.4.1 STREAMFLOW FILES

Note that “streamflow files” include files with actual streamflow data and files containing climatic data, such as rainfall and evaporation.

To specify the streamflow file(s):

Click on the *Files::Streamflows* menu item from the REALM Setup window (Figure 6-3) **or**

Click on the  ‘Specify flow files’ button.

The “Flow files dialog” box (Figure 6-10) is displayed.

Click on row 1 and then on the **Browse...** button to browse through to the required directory. Note that the above operation takes the user to the current project directory (i.e. in this case *C:/realm1*).

Double-click on the required streamflow file **or**

Select the required streamflow file and click **Open**. This will display the streamflow file with its path on row 1, as shown in Figure 6-10.

For applications with several streamflow files, follow the above procedure (for row 2 etc.) to select the other streamflow files.

Click on **OK** to close the “Flow files dialog” box and return to the REALM Setup window (Figure 6-3).

The **Cancel** button takes the user back to REALM Setup window, without saving the entered information in Figure 6-10.

6.4.2 DEMAND FILES

To specify the demand file(s):

Click on the *Files::Demands* menu item from the REALM Setup window (Figure 6-3) **or**

Click on the  ‘Specify demand files’ button.

The “Demand files dialog” box is displayed (which is very similar to the “Flow files dialog” box as shown in Figure 6-10 for streamflow files).

Follow the same procedure to select demand file(s), as for streamflow file(s).

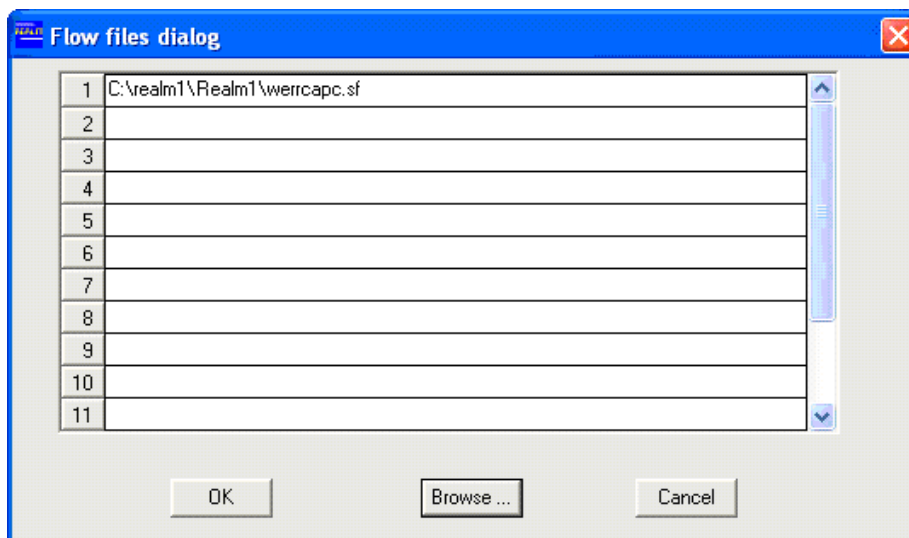



Figure 6-10 Streamflow Files Dialog Box with a Streamflow File

6.4.3 CROP MODEL DATA FILES

To specify the input file(s) for the irrigation demand models:

Click on *Files::Irrigation Demand Model* menu item of the REALM Setup window used or

Click on the  'Specify irrigation demand model files' button.

The "Irrigation demand model files dialog" box is displayed. The operations are very similar to the "Flow files dialog" box and therefore, follow the same procedure to select irrigation demand model file(s) as for streamflow file(s).

It should be noted that irrigation demand model files must always be entered at a daily time step regardless of whether the REALM model is daily, weekly or monthly. This is because irrigation demand models require daily input data. A typical irrigation demand model input file is shown in Figure 6-11. It can be seen that the same structure as for streamflow and demand files should be followed. The main difference is that the first line of the file (identifying line) should be #####7.

```

RodneyClimREALMFormat.prn - Notepad
File Edit Format View Help
####7
Rodney - climate data file from file "climate modify 1891-2005.prn" or "climate modify 91-05.prn"
1/1/1891 TO 1/6/2006
UKM
( 218,378.2)
$
SEASON
YEAR
RODNEY-BC215 EVAP
RODNEY-BC218 RAIN 1
RODNEY-BC218 RAIN 2
1 1891 7.20 0.00 0.00
2 1891 7.80 0.00 0.00
3 1891 7.50 0.00 0.00
4 1891 7.80 0.00 0.00
5 1891 7.90 0.00 0.00
6 1891 7.90 2.40 2.40
7 1891 7.40 4.80 4.80
8 1891 8.20 0.00 0.00
9 1891 8.30 14.60 14.60
10 1891 8.60 2.60 2.60
11 1891 7.40 0.00 0.00
12 1891 7.90 0.00 0.00
13 1891 7.50 0.00 0.00
14 1891 8.10 0.00 0.00
15 1891 8.00 0.00 0.00
16 1891 8.10 0.00 0.00
17 1891 8.60 13.80 13.80
18 1891 8.20 2.60 2.60
19 1891 7.90 0.00 0.00
20 1891 8.00 0.00 0.00
21 1891 8.00 0.00 0.00
22 1891 7.90 0.00 0.00
23 1891 7.60 0.00 0.00
24 1891 7.70 0.00 0.00
25 1891 7.60 0.00 0.00
26 1891 7.50 0.00 0.00
27 1891 7.70 0.00 0.00
28 1891 7.30 0.00 0.00
29 1891 7.80 0.00 0.00
30 1891 8.00 0.00 0.00
31 1891 7.60 0.00 0.00
32 1891 7.90 0.00 0.00
33 1891 8.20 0.00 0.00
34 1891 7.80 0.00 0.00
35 1891 7.80 0.00 0.00
36 1891 7.60 0.00 0.00
37 1891 7.40 0.00 0.00
38 1891 7.90 0.00 0.00
39 1891 8.00 0.00 0.00
40 1891 7.60 0.00 0.00
41 1891 7.30 0.00 0.00
42 1891 6.90 0.00 0.00
43 1891 6.70 0.00 0.00
44 1891 7.50 0.00 0.00
45 1891 7.00 0.00 0.00
46 1891 7.10 0.00 0.00
47 1891 7.80 0.00 0.00
48 1891 7.40 0.00 0.00
49 1891 7.20 0.00 0.00
50 1891 7.10 0.00 0.00
51 1891 6.80 0.00 0.00
52 1891 6.70 0.00 0.00
53 1891 6.90 0.40 0.40
54 1891 6.50 0.00 0.00
55 1891 6.80 0.00 0.00
56 1891 6.90 0.00 0.00
57 1891 6.80 0.00 0.00
58 1891 6.70 0.00 0.00
59 1891 6.60 0.00 0.00
60 1891 6.10 0.00 0.00
61 1891 6.70 0.00 0.00
62 1891 6.10 0.00 0.00
63 1891 6.30 0.00 0.00
64 1891 6.40 0.00 0.00
65 1891 5.70 0.00 0.00

```

Figure 6-11 Example Irrigation Demand Model Input File

To ensure no confusion between REALM system files and irrigation demand models, the column names in irrigation demand models cannot be referenced in variable capacity carriers, stream junction or reservoir inflows, or demand node names. Additionally, column names in the streamflow or demand files cannot be referenced within irrigation demand models.

6.5 INITIAL CONDITIONS

It is necessary to specify certain initial conditions for REALM runs. They are:

- Running total variables
- Initial reservoir volumes (or storage volumes at the start of simulation period)
- Initial irrigation deliveries (only when DC2 nodes are present in the system files)
- Water quality initialisation (only for water quality modelling applications)
- Carrover volumes (only when DC2 nodes with carryover are present in the system files).


6.5.1 RUNNING TOTAL VARIABLE INITIALISATION

Variable initialisation is provided to allow any variable which refers to a previous time step in a variable capacity carrier to be initialised. This refers to variable types such as -CAP and -FLO, which refer to the last time step, as well as running total variables such as RFxx and {xxx, whose values are dependent on multiple previous time steps.

It should be noted that if the user does not specify initial values for these variables, an initial value of 0 is adopted as default by REALM.

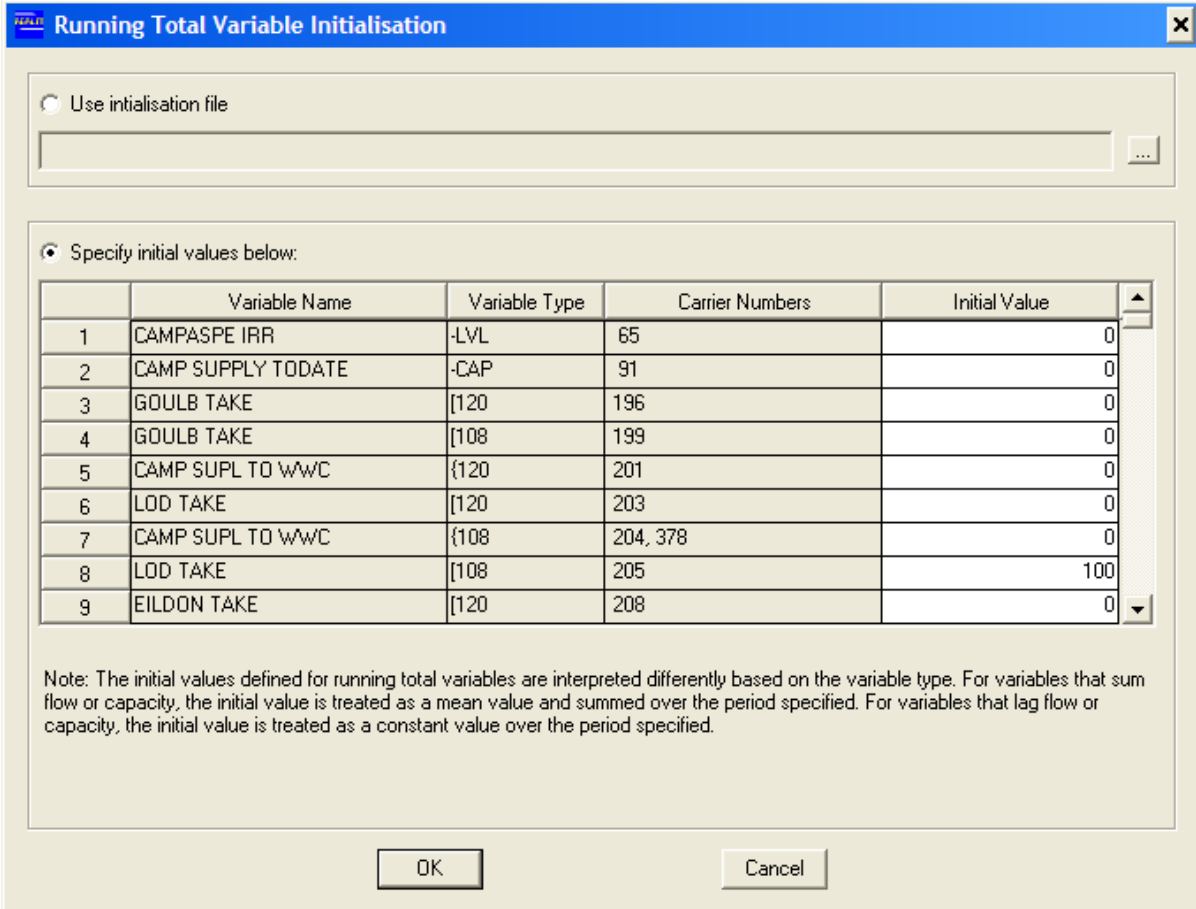
To specify initial running totals:

Click on the *Initialisation::Running Totals* menu item of REALM Setup window (Figure 6-3) or

Click on the  'Initialise running total variables' button.

The "Running Total Variable Initialisation" dialog box (Figure 6-12) is displayed.

There are two ways of initialising these variables. The first option is to use an initialisation file. To do this, select the 'Use initialisation file' radio button. This allows a filename to be specified in the field below. A file can also be selected using the browse button immediately to the right of the filename field.



The dialog box titled "Running Total Variable Initialisation" contains two radio buttons: "Use initialisation file" (unselected) and "Specify initial values below:" (selected). Below the first radio button is a text field with a browse button "...". Below the second radio button is a table with 5 columns: "Variable Name", "Variable Type", "Carrier Numbers", and "Initial Value". The table contains 9 rows of data. Below the table is a note explaining that initial values are interpreted differently based on variable type. At the bottom are "OK" and "Cancel" buttons.

	Variable Name	Variable Type	Carrier Numbers	Initial Value
1	CAMPASPE IRR	-LVL	65	0
2	CAMP SUPPLY TODATE	-CAP	91	0
3	GOULB TAKE	[120	196	0
4	GOULB TAKE	[108	199	0
5	CAMP SUPL TO WWC	{120	201	0
6	LOD TAKE	[120	203	0
7	CAMP SUPL TO WWC	{108	204, 378	0
8	LOD TAKE	[108	205	100
9	EILDON TAKE	[120	208	0

Note: The initial values defined for running total variables are interpreted differently based on the variable type. For variables that sum flow or capacity, the initial value is treated as a mean value and summed over the period specified. For variables that lag flow or capacity, the initial value is treated as a constant value over the period specified.

Figure 6-12 Variable Initialisation Dialog Box

The initialisation file is of the same format as the *endoars* file, which is generated at the end of every REALM run. The file includes a list of all running total variables in the system file and their values at the end of the run (which also may be used as initial values). An example of this file is shown in Figure 6-13.

The simplest way to prepare a variable initialisation file is simply to modify an existing one from a previous REALM run, preferably for the same system file. The file consists of a list of every running total variable in the system file, constructed as the variable name (typically a carrier) and the variable type. The data at the bottom of the file is the values that will be used to initialise each variable.

```

REALM running total variables end value
Test run

date: 13:39:15 22/07/11

(2f6.0.37f12.0)
37
replicate
restart rec
CAMPASPE IRR -LVL
CAMP SUPPLY TODATE -CAP
GOULB TAKE [120
GOULB TAKE [108
CAMP SUPL TO WWC {120
LOD TAKE [120
CAMP SUPL TO WWC {108
LOD TAKE [108
EILDON TAKE [120
EILDON TAKE [108
CAMP SUPL TO WWC -FLO
LIMIT CAMP WWC CAP -CAP
#1 TO GMID TOT SUPP AF05
#2 TO GMID TOT SUPP AF05
GMID SHEP SUPP AF05
GOULB ALLOC -CAP
LAG1 G_ALLOC -CAP
EILDON REL#1 AF05
EILDON REL#1 -FLO
LIMIT EIL CAP -CAP
EILDON SPILLS -FLO
EILD FL PRE-RELEASE -FLO
ENV FLOOD#1 MEM -CAP
GOULB TAKE AC06
1 MTH EIL INFLOW RC12
1 MTH EIL INFLOW RC24
EIL 24 MTH TRIG INF -CAP
G_IRR YIELD AC06
G_OTH YIELD AC06
EFP PIPE 2H AF06
EFP PIPE 2L AF06
ELEC1 PUMP AF06
TO HEATHCOTE AF06
CAMP TO WWC TODATE -CAP
LODDON ALLOC -CAP
1 0 200 103184 15076443 13290296 63854 787234 55274 688696
    
```

Figure 6-13 Example Variable Initialisation File

Alternatively, the user can select the ‘Specify initial values below’ radio button in the “Running Total Variable Initialisation” dialog box. A list of the running total variables in the system file is then provided (listed by variable name, i.e. carrier name and variable type). The initial value for each running total variable can then be specified in the right-hand column.

Initialisation of different variable types

Take care when specifying initial values for variables, as the information will be read differently for different types. This is highlighted in Table 6-1.

Table 6-1 Running Total Variable Types

Variable Type	Description	Initial Value Read As
-FLO, -CAP, -LOS	Value from previous time step	Value from the previous time step
RFxx, RCxx, {xxx, [xxx	Sum of values of previous xxx time steps	Mean value from the previous xxx time steps
AFxx, ACxx	Sum of values of previous time steps since month xx	Mean value from the previous xxx time steps
~xxx, @xxx	Value from xxx time steps ago	Constant value for xxx time steps

This can be illustrated using two examples:

1. A running total variable summing flow in a carrier for the previous 24 time steps would have variable type RF24. REALM calculates the value of this variable during run time by keeping track of the previous 24 flow values and then summing them when required in an equation. Therefore, when


initialising this variable the user should select an average flow value that is appropriate for 24 time steps. If a value of 10 was used to initialise this variable, it would return a value of 240 when called in an equation in the first time step of the run. If the relevant carrier had a flow value of 20 in the first time step, then this variable would return a value of 250 when called in an equation in the second time step of the run (ie $23 \times 10 + 20$). It will take 24 time steps of the model run for this running total value to become independent of the initialised value.

2. Similarly, a running total variable that references the capacity of a carrier from 3 time steps previously would have variable type @003. If this variable is initialised with a value of 10, it will return that value for the first three time steps of the model run when called in an equation. In the fourth time step it will return the capacity value of the relevant carrier from the first time step.

6.5.2 INITIAL RESERVOIR VOLUMES

To specify initial reservoir volumes:

Click on the *Initialisation::Reservoirs* menu item of the REALM Setup window (Figure 6-3) or

Click on the  'Initialise reservoir volumes' button.

The "Initial Reservoir Volumes" dialog box (Figure 6-14) is displayed. There are three options available to specify the initial reservoir volumes, as follows:

1. Use of reservoir initialisation file
2. Specification of initial reservoir volumes
3. Setting initial volumes to full supply capacity.

The initial storage volumes of all reservoirs included in the system file (or in the first system file in case of multiple system files) of the current REALM application should be specified using the above options. The initial storage volumes of new reservoirs in the second and subsequent system files of multiple system file runs are assumed to be zero.

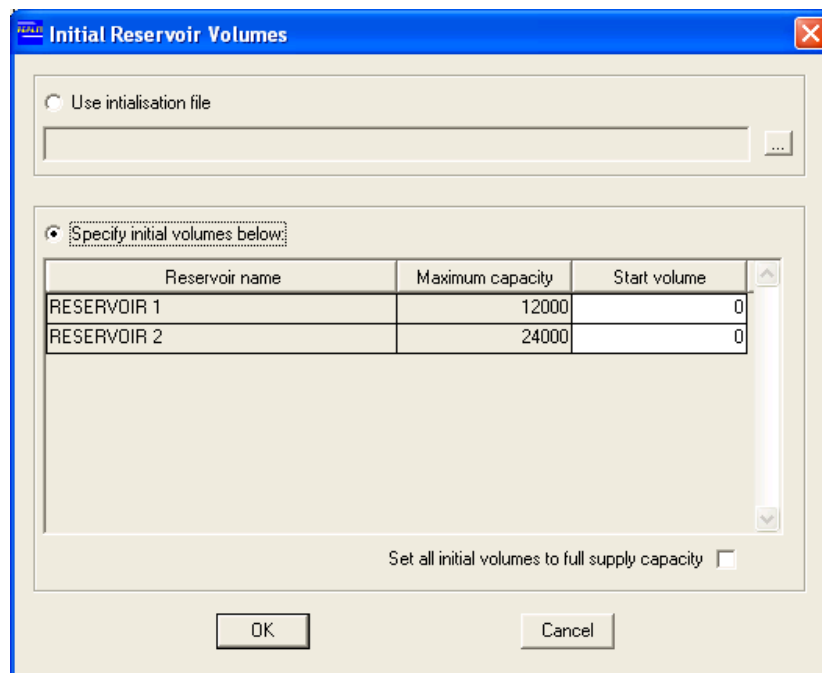


Figure 6-14 Initial Reservoir Volume Dialog Box


Use of reservoir initialisation file

The reservoir initialisation file is a standard REALM format file similar to streamflow, demand and REALM format output files, and therefore the structure of the file is same as that of a REALM format file. Figure 6-15 shows a reservoir initialisation file. The easiest way to prepare this file is to edit an existing 'endstor' file (i.e. an output file of REALM containing end storage volumes of reservoirs of a previous simulation run). The 'endstors' file is described in Section 7.2.3

The first line of the reservoir initialisation file contains a title. The next four lines contain some description of the file, followed by the FORTRAN format statement as in streamflow and demand files (Chapters 2 and 3). The next line indicates the number of columns in this file, and is followed by the column names in the next few lines. The last line contains the data according to the above FORTRAN format statement. The REPLICATE column is optional for a single replicate run, but necessary for multiple replicate runs. The second column is optional for both single and multiple replicate runs. Although Figure 6-15 was prepared for a single replicate run, the first two columns were included in this file, since this file was prepared from an 'endstors' file of a previous REALM simulation. For a multi-replicate run, the start storage volumes should be given for each streamflow replicate in Figure 6-15. Note also that there is only one reservoir with the name of *Reservoir 1* included in this file, but there can be additional columns for multiple reservoirs. **The reservoir names in this file should be correctly spelled (including case) as in the system files of this application.**

To specify the reservoir initialisation file:

Click on 'Use initialisation file' radio button (Figure 6-14). This will activate the field next to the radio button.

Click on the  'Browse' button next to filename field. Use the standard browsing operations to locate and select the reservoir initialisation file from this directory or from any other directory. Files can be listed according to the file type to assist the user in selecting the required file. The available file types are *Initial reservoir (*.RI?)*, *Data files (*.dat)* and *All files (*.*)*.

```

REALM INITIAL STORAGES
Prepared by Chris Perera
Victoria University of Technology
Date: 07/06/2001
REALM User's Manual
(2F6.0, 1F12.0)
3
REPLICATE
restart rec
Reservoir 1
1      0      8729

```

Figure 6-15 Format of a Reservoir Initialisation File

To specify initial reservoir volumes:

Click on the radio button 'Specify initial volumes below' (Figure 6-14).

The names of all reservoir nodes and their maximum capacities are displayed (Figure 6-14). This list is assembled from the system file or the first system file where multiple system files are used. In simulations with multiple system files, new reservoirs specified in subsequent system files have initial storage volumes of zero.

Enter the starting volumes in the 'Start volume' column for each reservoir. The starting volume should be less than each reservoir's maximum capacity.

To set initial reservoir volumes to full supply level:

To assign the initial storage volumes of the reservoirs included in the system file (or the first system file in case multiple system files) equal to their maximum capacities, tick the check box 'Set all initial volumes to full supply capacity'.

Once the user has entered initial storage volumes of the reservoirs through one of the above methods, clicking on **OK** takes the user to the REALM Setup window (Figure 6-3). The **Cancel** button also takes the user back to Figure 6-3, but without saving the entered information in Figure 6-14.

6.5.3 INITIAL IRRIGATION DELIVERIES

If there are Irrigation or Rural demand nodes (i.e. DC2 nodes) present in the system file (or the first system file in case of multiple system files), it is necessary for the user to enter the initial irrigation deliveries with respect to these DC2 nodes. These are the deliveries that have already being made for the current irrigation season from the start of the irrigation season to the start of simulation (which is also within the irrigation season). [Note that the definition of the irrigation season is different to the season terminology used in REALM (which is days, weeks and months). The irrigation season is the period from the start-of-irrigation to the end-of-irrigation. For example, the irrigation season in Victoria is from August to May.]

To specify initial irrigation deliveries:

Click on the *Initialisation::Irrigation demands* menu item of the REALM Setup window (Figure 6-3) **or**

Click on the  'Initialise y.t.d. irrigation deliveries' button.

The “Initial deliveries to-date for irrigation demands” dialog box is displayed (Figure 6-16). This dialog box lists the names names of all DC2 nodes (Figure 6-16). This list is assembled from the system file or the first system file where multiple system files are used.

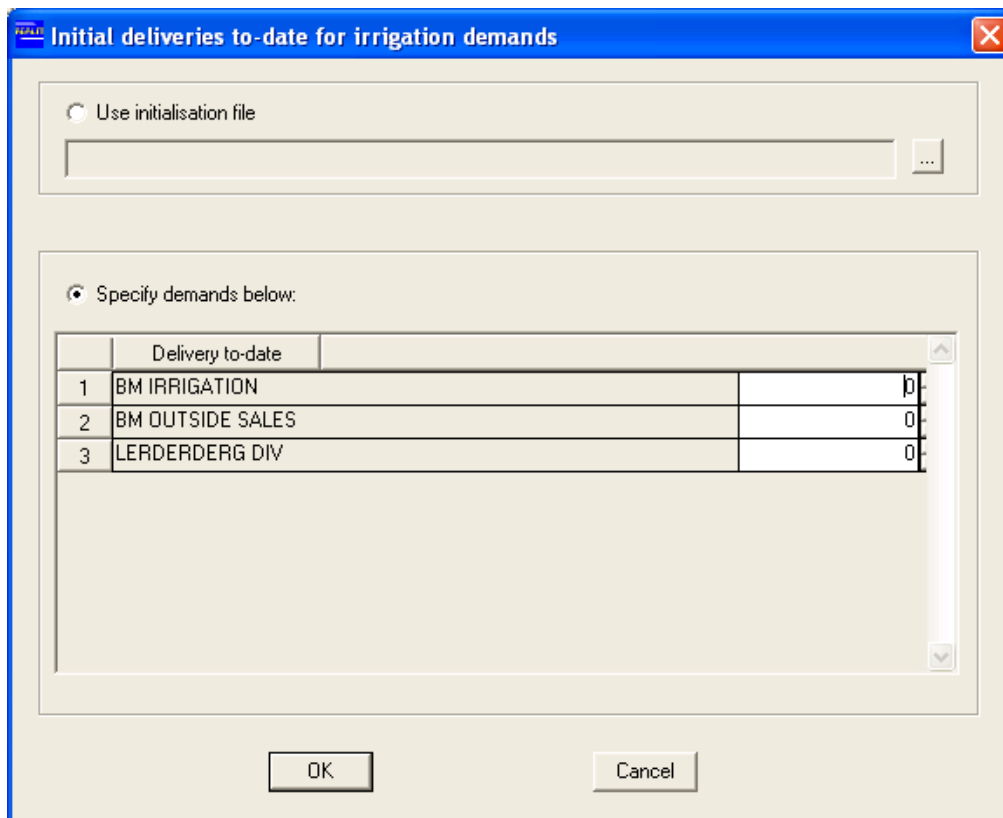


Figure 6-16 Initial Irrigation Deliveries Dialog Box

There are two options to specify the start-up deliveries, as follows:

1. Use of an irrigation delivery initialisation file
2. Specification of initial irrigation deliveries.

In simulations with multiple system files, new DC2 nodes specified in subsequent system files have initial deliveries of zero.

To specify the irrigation deliveries initialisation file:

Follow the instructions as for the “Initial reservoir volume” dialog box (Figure 6-14) to use an irrigation delivery initialisation file to input initial irrigation deliveries.

The irrigation delivery initialisation file is a REALM format file and is similar to the

reservoir initialisation file of Figure 6-15. Also, it has the similar structure to the End Irrigation Delivery file (i.e. *enddem*s), which is created from a REALM simulation run. The *enddem*s file is described in Section 7.2.3. Therefore, the easiest way to prepare the irrigation delivery initialisation file is to modify an *enddem*s file created from a previous REALM application, preferably for the same system. A typical irrigation delivery initialisation file is shown in Figure 6-17. As in Figure 6-15, the first two column names in Figure 6-17 are optional for a single replicate run. However, the REPLICATE column is necessary for multiple replicate runs. **The irrigation demand names in the irrigation delivery initialisation file should be correctly spelled (including case) as in the system files of the application.**

```

REALM CUMULATIVE CURRENT SEASONS IRRIGATION DEMANDS
Realm Worked Example Manual
Tutorial 7 Irrigation restriction policy
Date: 19:08:49 11/20/98

(2F6.0, 3F9.0)
5
REPLICATE
restart rec
BM IRRIGATION
BM OUTSIDE SALES
LERDERDERG DIV
1 0 0 0 0

```

Figure 6-17 Format of Irrigation Delivery File

To specify initial irrigation deliveries:

Click on the 'Specify demands below' radio button (Figure 6-16).

Enter the initial irrigation deliveries in the fields next to the irrigation demand names.

Once the user has entered the initial irrigation deliveries through one of the above methods, click on **OK** to take the user back to the REALM Setup window (Figure 6-3). The **Cancel** button also takes the user to the same window, but without saving the entered information.

6.5.4 WATER QUALITY INITIALISATION

If water quality is to be modelled in the REALM application, it is necessary to specify the start concentrations of water quality variables in reservoirs. A separate file is required for each water quality variable that is modelled in the REALM simulation.

To specify initial water quality:

Click on the *Initialisation::Water quality* menu item of REALM Setup window (Figure 6-3) **or**

Click on the  'Specify water quality start levels' button.

The "Water quality start level specification" dialog box (Figure 6-18) is displayed. In Figure 6-18, only two water quality variables (namely *ec* and *turb*) are present, since they are the only two water quality variables included in the system file (or in the first system file in case of multiple system files).

Click on the field next to the relevant water quality parameter (e.g. *ec*) and use the

Browse button to locate the corresponding water quality initialisation file.

Select the file.

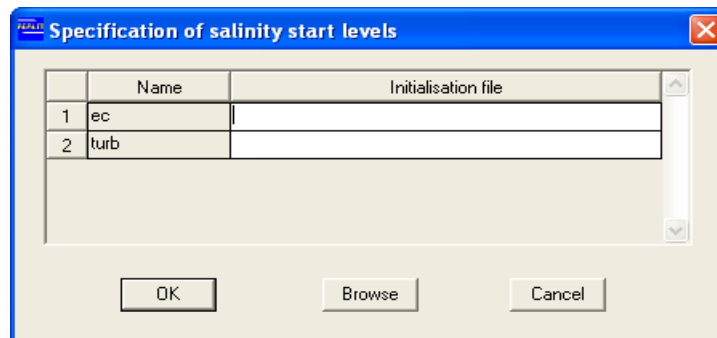


Figure 6-18 Water Quality Start Level Specification Dialog Box

The water quality initialisation files are also in standard REALM format. A sample initial concentration file for water quality variable of *ec* is shown in Figure 6-19. In this file, 200 *ec* units are considered as the initial concentration of *Reservoir 1*. There can be any number of reservoirs in this file, which are compatible with the system file (or the first system file in case of multiple system files). Any missing reservoirs (or mis-spelled) reservoirs are assigned zero initial concentrations. **Therefore, it is necessary to correctly spell (including case) the reservoir names in these files as in system file.** For multiple system file runs, the initial concentrations of new reservoirs in second and subsequent system files are considered zero. Similar to the reservoir initialisation file and initial irrigation delivery file, the REPLICATE column is optional for single replicate REALM runs, but necessary for multiple replicate runs.

```

startec
Electrical conductivity
Prepared by Chris Perera
TEST DATA
DATE : 20 JUL 1990
(F6.0,F12.2)
  2
REPLICATE
Reservoir 1
  1      200.00

```

Figure 6-19 Initial Concentration File for a Water Quality Parameter

6.5.5 CARRYOVER INITIALISATION

If there are Irrigation or Rural demand nodes (i.e. DC2 nodes) present in the system file, and any of those nodes model carryover (Section 5.5.2.4) it is necessary for the user to enter the initial volumes of carryover.

To specify initial carryover volumes:

Click on the *Initialisation::Carryover* menu item of the REALM Setup window (Figure 6-3) or

Click on the  'Initialise carryover' button.

The "Carryover Initialisation" dialog box is displayed (Figure 6-20). As for

initialisation of other variables, there are two options to specify the start-up carryover volumes, as follows:

1. Use of an initialisation file
2. Specification of initial carryover volumes.

If the 'Use initialisation file' radio button is selected, the user is then able to browse to the initialisation file. The carryover initialisation file must be in standard REALM format (Figure 6-21). For each DC2 node with carryover, 3 variables are specified:

ACVR (Total actual carryover volume): For nodes where carryover is modelled **with** spillable water accounts (Section 5.5.2.4) enter the relevant volume, taking care to ensure that the unit used (e.g. ML) is consistent with the rest of the model. For nodes where carryover is modelled **without** spillable water accounts, enter zero

CVRL (Actual low reliability share carryover): For nodes where carryover is modelled **with** spillable water accounts (Section 5.5.2.4) enter zero. For nodes where carryover is modelled **without** spillable water accounts, enter the relevant volume.

CVRH (Actual high reliability share carryover): For nodes where carryover is modelled **with** spillable water accounts (Section 5.5.2.4) enter zero. For nodes where carryover is modelled **without** spillable water accounts, enter the relevant volume.

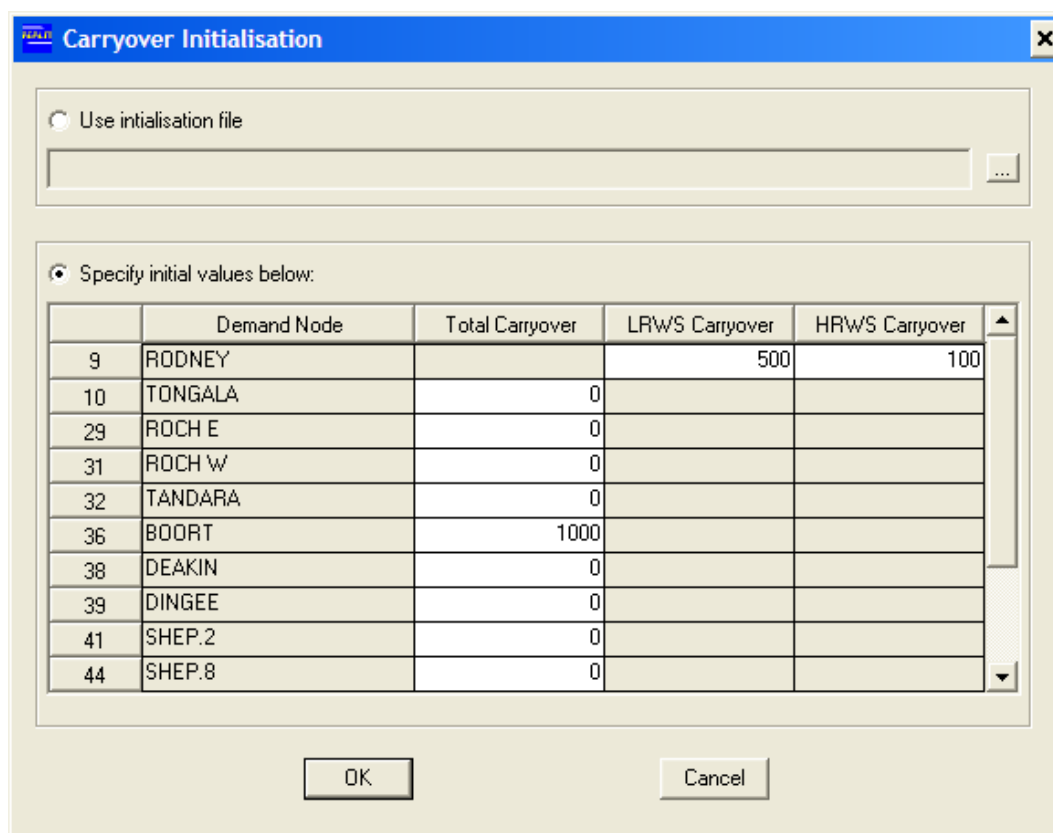


Figure 6-20 Carryover Initialisation Dialog Box

```

REALM carryover start value
System file updated from GoulN905.sys.
  date: 13:58:18 09/07/12

(2f6.0, 6f12.0)
  8
replicate
restart rec
RODNEY          ACVR
RODNEY          CVRL
RODNEY          CVRH
TONGALA         ACVR
TONGALA         CVRL
TONGALA         CVRH

      0      2000      1000      300      0      0

```

Figure 6-21 Format of Carryover Initialisation File

Alternatively, if the the ‘Specify initial values below’ radio button is selected, the user is able to directly enter the start-up carryover volumes in the “Carryover Initialisation” dialog box. This dialog box lists the numbers and names of all nodes with carryover (Figure 6-20). Note that for irrigation nodes where carryover is modelled with spillable water accounts, only the ‘Total Carryover’ field is active. For nodes where carryover is modelled without spillable water accounts, only the fields ‘LRWS Carryover’ and ‘HRWS Carryover’ are active. In Figure 6-20 Rodney is the only demand node with carry over but without spillable water accounts.


6.6 REALM FORMAT OUTPUT FILES

REALM can generate several output files, which have the same format as the streamflow and demand files. The output files fall into different categories as given below:

- reservoirs (seven output options)
- demands (six output options)
- stream junctions (one output option)
- carriers (four output options)
- water quality (two output options).

[REALM also retains the capacity to generate three output options for gravity diversion nodes. However, this function is active only when the system file has been generated in an old version of REALM, and includes gravity diversion nodes.]

For each of these categories except water quality, an output file is created if each option is selected. However, when water quality options are selected, an output file is created for each water quality parameter that is modelled in REALM. This is explained in detail in Section 1.1.1.

The user may want to create certain output files during a REALM run or the user may want to store all results of the REALM run in a database for later use. The user can select these options by clicking on *Output* menu item of the REALM Setup window (Figure 6-3). Alternatively, the user may click on the  ‘Select output

options' button. The “Select data sets to be saved” dialog box (Figure 6-22) is displayed.

Before displaying this dialog box, the REALM Setup (S) has already read the system file(s) and identified the types of nodes in the system file(s) for which output files can be generated during the REALM simulation. For example, the data compartment for water quality in Figure 6-22 is inactive, since the system file used in the current REALM setup does not model water quality.

As can be seen, there are 4 options in the radio button panel at the top of this dialog box as listed below.

- Select individually
- Select all
- De-select all
- Output all to data base.

Clicking on the radio button ‘*Select individually*’ allows the user to select the required output files individually for the REALM run. Click on only the required file items. For example, clicking on the ‘*Restriction level*’ item in the ‘*Demand data*’ compartment will create an output file when REALM is run, which contains the demand restriction level information.

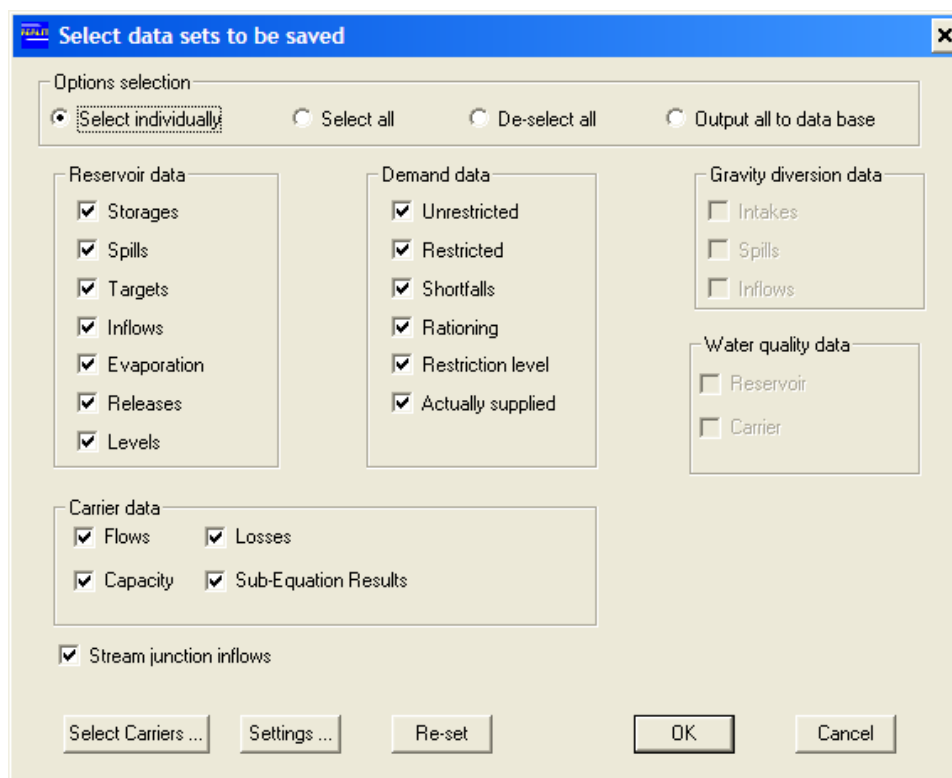


Figure 6-22 Select Data Sets to be Saved Dialog Box

The ‘*Select all*’ radio button selects all output files relevant to the system file(s), whereas the ‘*Output all to data base*’ radio button allows the user to store all results of the REALM simulation run in a binary database. The ‘*De-select all*’ radio button

cancels all operations done under the other three radio buttons.

Once the output selections are made, if the user wishes to reset the output option parameters to what he/she originally had (before the changes), the user can click on the **Reset** button (of the button panel at the bottom). This will display the output settings that the user had before any changes.

Click on **OK** to close the “Select data sets to be saved” dialog box and return to the REALM Setup window (Figure 6-3). The **Cancel** button also takes the user back to the same window, but without saving modified output settings.

If the options under the “Carriers data” block are selected, the user should select the carriers to be included in the output file(s). This may be very useful for applications with system files having large number of carriers and if the user is interested in information only on certain carriers. The default is no carriers selected. The selection of carriers is explained in Section 6.6.1.

It is also possible to save the output options settings for later loading and modification. This aspect is explained in Section 6.6.2.

6.6.1 CARRIERS

If carrier output options (i.e. ‘Flows’, ‘Capacity’, ‘Losses’ and/or ‘Sub-Equation Results’) are selected, clicking on the **Select Carriers** button allows the user to select individual carriers in the output files. As stated earlier, this is useful when a system has a large number of carriers and the user does not want to study the results of all these carriers. This is designed to reduce the size of the carrier output files.

By clicking on the **Select Carriers** button, a dialog box (Figure 6-23) with the complete list of carriers will be displayed, with all the carriers extracted from all the system files of this REALM application. The user can select carriers to be included in the carrier output files, by ticking the boxes next to the carrier names. The results of REALM (i.e. flows, capacity and/or losses) for all selected carriers will be included in the carrier output files. Note that if more than 97 carriers are selected, a dialog box with the following text is displayed: “You have selected >97 carriers, which is more than some REALM utilities can process. Do you wish to proceed?”

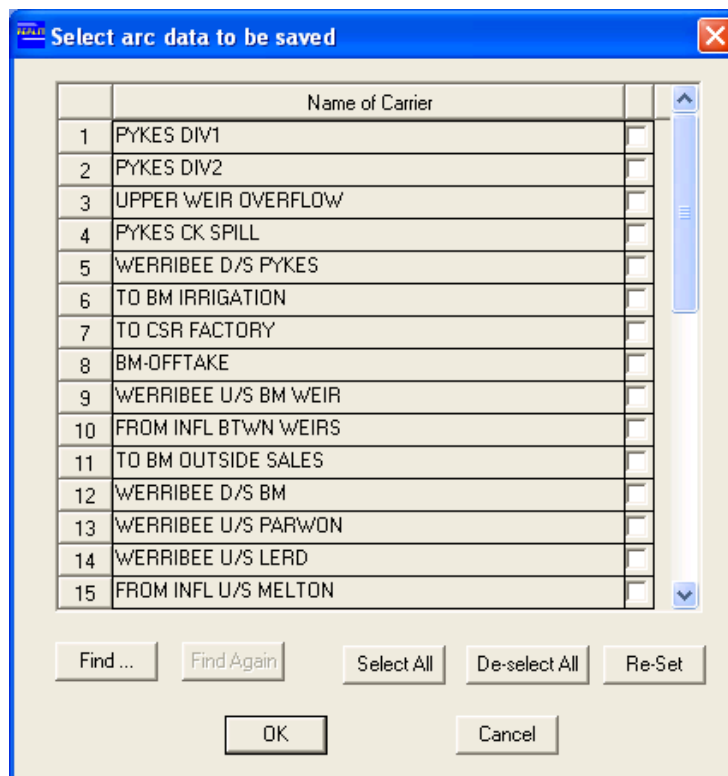


Figure 6-23 Selection of Carriers Dialog Box

The **Select All**, **De-select All**, **Re-Set**, **OK** and **Cancel** buttons are similar to Figure 6-22. The **OK** button takes the user back to Figure 6-22, after saving information on selected carriers. The **Cancel** button also takes the user back to Figure 6-22, but without saving the selection. The **Find** button allows the user to find a carrier with its name or part of the name. Clicking on the **Find** button allows the user to enter the name of the carrier (or a part of the name) to search for carriers with the entered string.

Entering the carrier name (or a part of a name) and clicking on the **OK** button will display carriers again, as shown in Figure 6-23. If there is a match then this match will be definitely shown in the list. Note that Figure 6-23 also has the **Find again** button, which allows the user to select the next carrier in the list with the (same) searching string.

6.6.2 SAVING/LOADING OUTPUT SETTINGS

The user is able to save up to 5 output settings and load any of these saved settings later for other REALM setups. This is done by clicking on the **Settings** button in Figure 6-22, which displays the “Output scenario selection” dialog box (Figure 6-24).

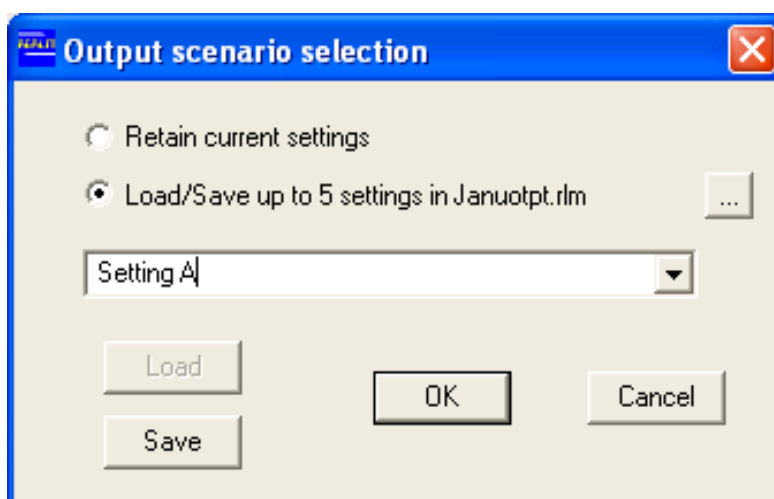


Figure 6-24 Output Scenario Selection Dialog Box

The user can also load these saved settings in the database extraction utility (Section 8.12) to extract certain output information from the database output.

To save output settings:

Click on the 'Load/Save up to 5 settings in <output filename>.rlm' radio button (in Figure 6-24, it is 'Load/Save up to 5 settings in Januotpt.rlm', where *Janu* is the first four characters of the log filename and *otpt* is a keyword) to save the current setting. This will activate the field below this radio button. Enter a name for the setting (it is shown as *Setting A* in Figure 6-24). If the user wants to save the current output settings as *Setting A* in *Januotpt.rlm* file under the project directory, then click on the **Save** button. After saving, Figure 6-24 re-appears with *Setting A* shown in the list. Click on the **OK** button to take the user back to Figure 6-22.


To load an output setting:

To load a previously saved output setting, click on the **Settings** button in Figure 6-22. This will display Figure 6-24. One saved setting, the *Setting A* can be seen in this figure (since it has already been saved), but there can be up to 5 saved settings. Note that by default, settings in the project directory are shown. If the user wishes to load an output setting from a different directory, then select the required directory, and open the *xxxxotpt.rlm* file, which shows the saved output settings in this file. (Note that 'xxxx' is the first four letters of a REALM log filename. It is also necessary that this REALM run defined by this log file is consistent with the REALM run and system files used in the current REALM setup). After selecting the required setting, click on the **Load** button to load the setting. Click on **OK** to return to Figure 6-22, with the loaded output settings.

To retain the current setting:

Clicking on the 'Retain current setting' button will allow the user to retain the current setting displayed in Figure 6-22, but this needs to be done before clicking on the **Load** button.

6.7 EXIT

Click on *Return* or the  'Return to main program' button of the REALM Setup (Figure 6-3) to return to the REALM Program Manager (Figure 4-1). This will display

the Exiting Setup dialog box. Click on **Update and exit** to use the current scenario to update the REALM setup file, and to return to the REALM Program Manager. This process will create the REALM setup file called *ans_file.dat*, required for running REALM simulation. **If the *ans_file.dat* file already exists in the project directory, then this file will be updated (or overwritten).**

The user can exit without updating the *ans_file.dat* by clicking on **Exit without updating** button. In this case, the changes done to the scenario will not be saved into the *ans_file.dat* which will eventually force REALM simulation to run according to the previous settings saved under the same file.

Instead of exiting or saving, the user can return back to the Setup window to do more changes by clicking on the **Stay in Setup** button.

Chapter 7

7 SIMULATION AND OUTPUT FILES

7.1 SIMULATION

Once the run time parameters are set up through REALM Setup (S) as in Chapter 6, the user is now ready to run the REALM simulation.

To run the REALM simulation:

Click on the *Run::Model* menu item (Figure 7-1) **or**

Click on  'Run REALM' button of the REALM Program Manager (Figure 4-1).

REALM then reads the setup information from the file *ans_file.dat* (that was created by REALM Setup), opens the required input and output files, and finally runs the simulation. As simulation progresses, each completed year is displayed on the **Run** progress box, together with the system file used. Section 7.1.1 details the common run-time error messages that may occur during simulation.

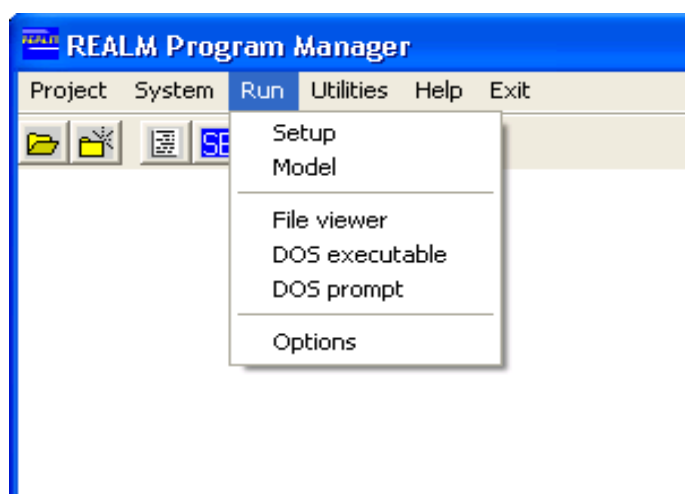


Figure 7-1 Run Menu Items of the REALM Program Manager

At the end of the simulation run, the "End run" dialog box (Figure 7-2) is displayed.

Click on **Yes** to view the log file which gives a broad overview and a summary of the results of the REALM simulation run.

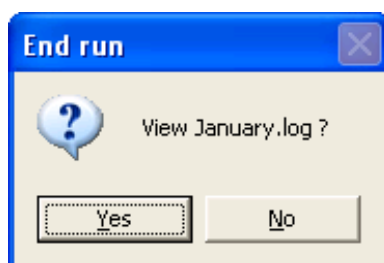


Figure 7-2 End Run Dialog Box

7.1.1 RUN-TIME ERRORS

Table 7-1 lists common run-time error messages and their meaning. During a model run, an error message will appear alerting the user if a run-time error has occurred. The run is paused while this message is displayed. If the user clicks **OK**, or does not respond to the message within 10 seconds, the run resumes. Note that this error message is only displayed the first time that an error is encountered, and not displayed for water-balance errors. At the end of the model run, if an error has been encountered, the following message will be displayed: "There was a water balance, convergence or equation error during the run. Refer to the log file for more information".

Table 7-1 Run Time Error Messages

Error	Action/Reasons
Maximum iteration count reached	Simulation has reached maximum number of iterations due to solution not converging in a time step. The user should investigate the extent of non-convergence and its suitability for the purpose for which the model results are being used.
No demand data for season/year	Simulation run dates (season and year) do not coincide with dates in demand file(s).
No S/F data for month (too >)	Simulation run dates (season and year) do not coincide with dates in streamflow file(s).
INFEASIBLE LP SOLUTION. NSTOP = 16	Network Linear Program has failed to provide a solution for the network. This is usually caused by carrier capacity constraints and therefore it is necessary to investigate these 'bottleneck' carriers. Errors other than NSTOP = 16 are possible.
Failed to open output file(s)	Insufficient disk space or too many files opened.
Streamflow file has incorrect label	All streamflow files must have ####2 on the first line; similarly the demand files should have ####3.
Arc capacity operator not found	The named dependent variable(s) for a variable capacity carrier have not been found.
Demand data column missing	Every demand node name in the system file(s) should be matched with a column name in the demand file(s).
Climatic data column missing	The named climatic data variable has not been found in the streamflow file(s).
Missing RV evaporation input	The named evaporation variable has not been found in the streamflow file(s). Same comment applies to the rainfall variable.
Failed to read the first line of file	REALM could not read the system file.
Invalid calculation is encountered in a carrier equation. Such invalid operations include division with a denominator of or close to zero, square root of a number less than zero and logarithmic of a number less than or equal to zero. An example of such error message is "Cannot solve division equation with near zero denominator in variable capacity carrier [name of problem carrier]. Check carrier # [problem carrier number]. Result set to zero".	The capacity calculation for a variable capacity carrier has resulted in an invalid calculation. To overcome this error, the relevant carrier equation needs to be edited to remove the occurrence of such calculations. If appropriate, this can be done with an IF statement, for example if the denominator of a division is equal to zero then set the equation to zero.

7.2 OUTPUT FILES

REALM creates several sets of output files. They can be categorised into three sets of files, as follows:

- Log files
- REALM format output files (as selected from REALM Setup **S**, see Section 6.66.5.5)
- Other output files.

7.2.1 LOG FILES

Depending on whether the check box ‘Log error message to separate file’ in the “Files/Output” tab under “Run Options” settings (Section 4.4.7.5) is selected or not, REALM produces for each run two separate log files (normal log and other for run-time errors) or a single log file including the run-time errors. The log file summarises the input and output files and system changes used for the run. The optional simulation summary is also written to the log file, if requested during REALM setup (Figure 6-6).

The optional simulation summary is the starting point for analysing the system performance. It highlights minimum reservoir levels, demand shortfalls, restriction frequency, carrier flows etc. It can also be used to confirm that an overall water balance for the entire simulation period has been achieved.

An example of a log file is shown in Figure 7-3. The log file is divided into three segments as follows:

- A segment containing input files, system changes (if multiple system files are used) and streamflow replicates, convergence and tolerance parameters, and simulation time step.
- A segment containing the years of simulation. If a separate error log file is not requested, it will include warning and error messages found during the simulation. Table 7-1 explains these error messages. If a separate error log file is requested, it will include a note informing that errors have occurred in the run. The note will also include details of the error log file and direct user to refer to the error log file for details of the errors.
- A summary information segment (if requested during REALM Setup).

As seen in Figure 7-3, the summary segment consists of summaries of reservoirs, demand zones and carriers. However, this section also contains information on other nodes used (if applicable) and water quality information for relevant nodes and carriers. Several other log files containing wide variety of information are given in *REALM Worked Examples Manual* (Victoria University and Department of Sustainability and Environment, 2005).

In carrier modelling under REALM, losses are taken at the bottom end of the carriers. Therefore, the log file (and the carrier flow output file) contains flows corresponding to the upstream end (i.e. flow without losses).

```
HHHHH      HHHHHHHH      HHHHHH      H      HHHHHHHHHH
H  H      H      H  H  H      H  H  H
HHHHHHHHH  HHHHHH      HHHHHHHH      HHH      HHH  H  H
HHH  H  HHH      HHH  H  HHH      HHH  H  H
HHH  H  HHH      HHH  H  HHH      HHH  H  H
HHH  H  HHHHHHHH      HHH  H  HHHHHHHH      HHH  H  H
```

```
*****
*          REALM V6.28          *
*      SIMULATION LOG FILE      *
*****
```

Log filename : \\internal.vic.gov.au\DSE\UserDirs\Desktop\ex3b.log

Scenario file: \\internal.vic.gov.au\DSE\UserDirs\Desktop\scn3b.scn

Simulation label:
Tutorial 3 Sub-Problem (b)

Streamflow file(s):
Sf3.dat
Demand file(s):
Dem2.dat

Restrictions are ON

Instream flow requirements NOT limited to natural
Water quality calculations are OFF

Number of S/F Sequences: 1

Convergence tolerance (storage) 1 10th%
Other convergence tolerance 5 %
Arc convergence tolerance (abs) 100
Minimum iteration count 3
Maximum iteration count 51
Do convergence twice No

Date: 13:02:45 19/02/13

Time Step = Monthly

```

SYSTEM CHANGES:
No      Seas  Year  System File
-----
  1      1  1982   EX3B.SYS
-----
    
```

Total number of seasons:- 36

***** RUN TIME MESSAGES:- *****

****INPUT DATA TYPE= 1 ****

```

1982
EX3B.SYS
1983
1984
***** END RUN TIME MESSAGES *****
    
```

SUMMARY INFORMATION

Reservoir data:

	Name	Start Storage	File Inflow	Min Storage	Average Storage	Evapn	Release to river	Spill	End Storage
1	RESERVOIR 1	9000.	2083.	1000.	5844.	0.	0.	0.	9272.
2	RESERVOIR 2	8000.	2576.	4444.	17193.	0.	0.	0.	24000.
		17000.	4659.	0.	23037.	0.	0.	0.	33272.

Demand data:

	Name	Unrestrict	Restrict	Rationed	Shortfall	Supplied
1	DEMAND 1	1372.	1372.	1372.	0.	1372.
2	DEMAND 2	1706.	1706.	1706.	0.	1706.
		3078.	3078.	3078.	0.	3078.

Name	No	Ave	Max	No	Ave %	Max %	No	Ave %	Max %
	Rest	Rest lvl	Rest lvl	Ration	Ration	Ration	Short	Short	Short
1 DEMAND 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 DEMAND 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Pipe/River flows:

Name	flow	Capacity	Min	Max	Loss
1 CARRIER 1	1372.2	12000.0	0.0	2800.0	0.0
2 CARRIER 2	1705.6	24000.0	300.0	3100.0	0.0
3 CARRIER 3	707.0	24000.0	0.0	4716.0	0.0
4 CARRIER 4	391.3	24000.0	0.0	4232.0	0.0
5 River 1	387.3	99999999.0	0.0	4610.0	0.0
6 River 2	742.1	99999999.0	0.0	7690.0	0.0

0.

End run

Figure 7-3 Example of a REALM Simulation Log File

7.2.2 REALM FORMAT OUTPUT FILES

As outlined in Section 6.6, REALM can generate several output files, which fall into different categories.

Several examples of REALM format output files containing a wide variety of information are given in *REALM Worked Examples Manual* (Victoria University and Department of Sustainability and Environment, 2005).

Naming convention for output files:

The REALM format output files follow an explicit naming convention.

First four letters:	Given by the first 4 letters from the log filename specified at beginning of Setup program as shown in Figure 6-6 under Section 6.3.1.
Next four letters:	Given by the system to specify the aspect (property/characteristic) of the type of the output considered.
Extension two letters:	Given by the system to distinguish different types of output categories.

This is the standard convention for output filenames except for files containing water quality information. This filename convention is shown in Figure 7-4. The first four letters '....' are extracted from the log filename. For example, a REALM run with a simulation log filename of *testing.log* which had requested output files of reservoir storages, demand restriction levels, carrier flows and capacities will generate the corresponding output files named *testing.log*, *teststor.rv*, *testlols.dc*, *testflow.ar* and *testcapc.ar* respectively.

Reservoirs		Demands		Carriers		Stream junctions	
....stor.rv	storage volume	....unrs.dc	unrestricted demand	....flow.ar	flows	....infw.gw	inflows
....spil.rv	spills	....rest.dc	restricted demand	....capc.ar	capacities		
....targ.rv	targets	....shrt.dc	demand shortfall	....loss.ar	losses		
....infw.rv	inflows	....ratn.dc	rationed demand	....eqns.ar	sub-equation results		
....evap.rv	evaporation	....lvls.dc	restriction levels				
....rels.rv	releases	....supp.dc	supplied demand				
....lvls.rv	storage level						

Note:	First 4 letters of the log file is denoted by '....'				
	File extensions:	rv	Reservoirs	ar	Carriers (arcs)
		dc	Demands	gw	Stream junctions

Figure 7-4 Naming Convention of Output Files

Naming convention for water quality files:

The filename convention for water quality parameters is slightly different. The output files can be created for water quality in reservoirs and carriers. An output file is created for each water parameter modelled. The filename convention is shown below for these output files. The first four letters '....' are extracted from the log filename. The second four letters 'ββββ' are the water quality parameters that can be modelled with REALM. The name of the water quality parameter contains a maximum of four characters. If there are less than four characters defining a water quality parameter (e.g. ec), then only these characters will be in the place of 'ββββ'. Currently, REALM can model only 4 water quality parameters and the names of these water quality parameters are controlled by the *realm.set* file (which is in the project directory). The names of the water quality parameters (which are stored in *realm.set* file) can be changed through the "Water Quality" tab of the *Run::Options* menu item.

-ββββ.rv reservoir water quality
-ββββ.ar carrier water quality

For example, a REALM run with a simulation log filename of *testing.log*, which had requested output files for water quality parameters of *saln* and *turb* for reservoirs and carriers will generate the following output files:

- testturb.rv testturb.ar testsaln.rv testsaln.ar*

Figure 7-5 and Figure 7-6 show the REALM format output files generated for reservoir storage volume and reservoir water quality for parameter *turb* respectively. They are text (or ASCII) files containing columns of data with several lines of header information. They have the same format as the streamflow and demand files (Chapters 2 & 3). The structure of these files is explained in Section 7.2.2.1.

```

RESERVOIR STORAGE
ex6a.log                               Time :14:55:01 Date :12/20/97
water quality modelling - ex6a

(F4.0, 2F6.0, 1f12.2)
4
SEASON
YEAR
REPLICATE
Reservoir 1      ESTO
  1. 1982.      1.   7716.00
  2. 1982.      1.   6704.00
  3. 1982.      1.   5629.00
  ... ..      ... ..
  ... ..      ... ..
 10. 1982.      1.   9899.00
 11. 1982.      1.   9837.00
 12. 1982.      1.   9706.00
   1. 1983.      1.   9878.00
   2. 1983.      1.  10038.00
  ... ..      ... ..
  ... ..      ... ..
   8. 1984.      1.  20000.00
   9. 1984.      1.  20000.00
  10. 1984.      1.  20000.00
  11. 1984.      1.  20000.00
  12. 1984.      1.  20000.00

```

Figure 7-5 Reservoir Storage Volume Output File

```

RESERVOIR W/QUAL
ex6c.log                               Time :07:30:37 Date :02/03/98
water quality modelling - ex6b
%loss considered in reservoir.

(F4.0, 2F6.0, 1f12.2)
4
SEASON
YEAR
REPLICATE
Reservoir 1      turb
  1. 1982.      1.  1350.00
  2. 1982.      1.  1597.00
  3. 1982.      1.  2084.00
  ... ..      ... ..
  ... ..      ... ..
 10. 1982.      1.   1302.00
 11. 1982.      1.   1283.00
 12. 1982.      1.   1266.00
   1. 1983.      1.   1264.00
   2. 1983.      1.   1262.00
   3. 1983.      1.   1255.00
  ... ..      ... ..
  ... ..      ... ..
   8. 1984.      1.   1075.00
   9. 1984.      1.   1061.00
  10. 1984.      1.   1047.00
  11. 1984.      1.   1047.00
  12. 1984.      1.   1046.00

```

Figure 7-6 Reservoir Water Quality (Turb) Output File

7.2.2.1 STRUCTURE OF REALM FORMAT OUTPUT FILES

The structure of the REALM format output files is similar to the REALM streamflow and demand files. The user is referred to Chapters 2 & 3 for details of the structure of these files. The header information is as follows:

- Identifying label; self-explanatory. Examples are
RESERVOIR STORAGE for reservoir storage file
DEMAND SHORTFALLS for demand shortfall file
CARRIER CAPACITIES for carrier capacity file
RESERVOIR W/QUAL for reservoir water quality file
- Four lines containing the simulation label used in the REALM Setup windows (Figure 6-6) and the date and time.
- FORTRAN format statement
- Number of columns
- Column names.

The FORTRAN format of the output files is controlled by the *realm.set* file of the project directory. This controls the number of characters and decimals occupied by each column of output data. The FORTRAN format of the output files (which is stored in *realm.set* file) can be changed through the “Format” tab of the *Run::Options* menu item.

As can be seen from Figure 7-5 and Figure 7-6, the keywords SEASON, YEAR and REPLICATE are also included for each REALM format output file. Similar to the streamflow and demand data files, the values corresponding to column names are listed after the column labels. For multiple replicate runs, the results corresponding to each replicate are listed sequentially in the output files before the next time step is listed. A sample output file containing reservoir storage volumes of a multiple replicate run is shown in Figure 7-7. The number of streamflow replicates used in this REALM run was 4.

```

RESERVOIR STORAGE
test.log                               Time :14:45:36 Date :06-Dec-90
run 70      existing us cowwarr and ds glenmaggie

(F4.0,2F6.0, 1f12.2)
  7
SEASON
YEAR
REPLICATE
BLUE ROCK          ESTO
MOONDARRA          ESTO
THOMSON            ESTO
GLENMAGGIE         ESTO
  1. 1989.    1. 200000.00    30400.00    833012.00    370000.00
  1. 1989.    2. 200000.00    27680.00    782199.00    325531.00
  1. 1989.    3. 200000.00    24024.00    778017.00    333193.00
  1. 1989.    4. 200000.00    26998.00    778415.00    322842.00
  2. 1989.    1. 200000.00    29465.00    833352.00    366929.00
  2. 1989.    2. 198671.00    23186.00    772591.00    292697.00
  2. 1989.    3. 195800.00    22489.00    769210.00    307475.00
  2. 1989.    4. 196256.00    22870.00    766542.00    284297.00
  3. 1989.    1. 199996.00    25360.00    829299.00    352206.00
  3. 1989.    2. 194471.00    21680.00    764354.00    263884.00
  3. 1989.    3. 189912.00    20998.00    758430.00    280646.00
  3. 1989.    4. 188488.00    21373.00    755490.00    254840.00
  4. 1989.    1. 198470.00    25770.00    842599.00    370000.00
  4. 1989.    2. 190271.00    20320.00    754638.00    247503.00
  4. 1989.    3. 181392.00    19650.00    747706.00    265195.00
  4. 1989.    4. 178890.00    20020.00    744538.00    239964.00
  5. 1989.    1. 200000.00    30400.00    886149.00    370000.00
  5. 1989.    2. 187347.00    21424.00    755033.00    250702.00
  5. 1989.    3. 177192.00    18832.00    745482.00    294698.00
  5. 1989.    4. 174152.00    18741.00    735840.00    237774.00
  6. 1989.    1. 200000.00    30400.00    937549.00    370000.00
  6. 1989.    2. 183356.00    21462.00    758733.00    280782.00
  6. 1989.    3. 172992.00    18181.00    744384.00    328178.00
  6. 1989.    4. 176305.00    21623.00    741840.00    260954.00

```

Figure 7-7 Reservoir Storage Volume Output File for a Multiple Replicate Run

The column names of the output files are assembled from the system file(s) relevant to the system components (e.g. reservoirs, demands and carriers) and suffixed with the four letter extension used in naming the output file. For example, in Figure 7-5 and Figure 7-7, the reservoir names have been extracted from the system file(s) and suffixed with 'ESTO' (The values in these files are the end storages for the simulation time steps). Similarly, in Figure 7-6, the reservoir name has been extracted from system file(s) and suffixed with 'turb'.

7.2.3 END-OF-SIMUALTION VALUE OUTPUT FILES

After each successful REALM run, default end-of-simulation value output files are generated, as follows:

End Storage file: the file called *endstors* contains the end storage volumes for all reservoir nodes corresponding to the system file (or the last system file in case of multiple system files) analysed. The end storage volumes are produced for each replicate in a multiple replicate run.

End Irrigation Delivery file: the file called *enddems* contains the cumulative irrigation deliveries that have been made for the last simulation year from the start of the irrigation season of that year, for all irrigation demand nodes corresponding to the system file (or the last system file in case of multiple system files) analysed (i.e.

supplied demand). The irrigation deliveries are produced for each replicate, in a multiple replicate run. If DC2 nodes are not present in the system file(s), REALM generates the *enddem*s file, but with the header information only.

End Carryover file: the file called *endcarry* contains the end volume of carryover water for each irrigation demand node with carryover. In case of nodes for which carryover rules with Spillable Water Account are applicable, volume of total actual carryover (ATCV) is recorded and **the** volumes of carryover from allocation against high reliability water share (CVRH) and low reliability water share (CVRL) are not relevant and recorded as zeroes. For nodes with carryover but without Spillable Water Account, the volumes of carryover from allocation against high reliability water share (CVRH) and low reliability water share (CVRL) are recorded, and the volume of total actual carryover (ATCV) is not relevant and recorded as zeroes. Refer to Section 6.5.5 for further details on how to interpret the *endcarry* file.

End Running Total Variables file: the file called *endrtot* contains the end values for the running total variables in the system file (listed by variable name, i.e. carrier name, and variable type). Table 6-1 in Section 6.5.1 details the running total variable types.

End Water Quality file: If water quality is modelled, REALM generates a separate file with the name *endaaaa* for each water-quality parameter, where *aaaa* is the name of the relevant water quality parameter listed in *realm.set* file in the project directory. (The name of each water quality parameter contains a maximum of four characters.) These files contain the end concentrations of the relevant water-quality parameter for all reservoir nodes corresponding to the system file (or the last system file in case of multiple system files) analysed. These concentrations are produced for each replicate in a multiple replicate run.

The purpose of these end-of-simulation value files file is to re-start a simulation from the end-point of a previous run. This enables long simulation runs to be performed in stages. The user can use the appropriate end-of-simulation value files with necessary modifications (if required) to run a new REALM simulation. For example, the end-values for storage volumes for one simulation could be used to initialise the next simulation. [In REALM Setup this is done by activating the radio button 'Use initialisation file' (Figure 6-14) and entering the relevant file path and 'endstors'.]

Each time REALM is run, the previous end-of-simulation value files are overwritten.

7.2.4 SUB-EQUATION OUTPUT

Results of the individual sub-equations in each variable capacity carrier can be extracted from REALM. The *Sub-Equation Results* check box will be available if the current system file uses sub-equations. It can be checked to generate an output file called *xxxxeqns.ar*, which contains the results of each sub-equation in the model for each time step.

A sample *xxxxeqns.ar* file is shown in Figure 7-8. It can be seen that the sub-equations and primary equations in each carrier in the system file are listed. The column names are composed of the carrier name and a four letter type. Type PEQN refers to the primary equation for the carrier, and types EQ_A to EQ_Z refer to sub-equations A to Z. Type EQAA to EQZZ refer to sub-equations AA to ZZ. The data in the file is the result of each equation for each time step.

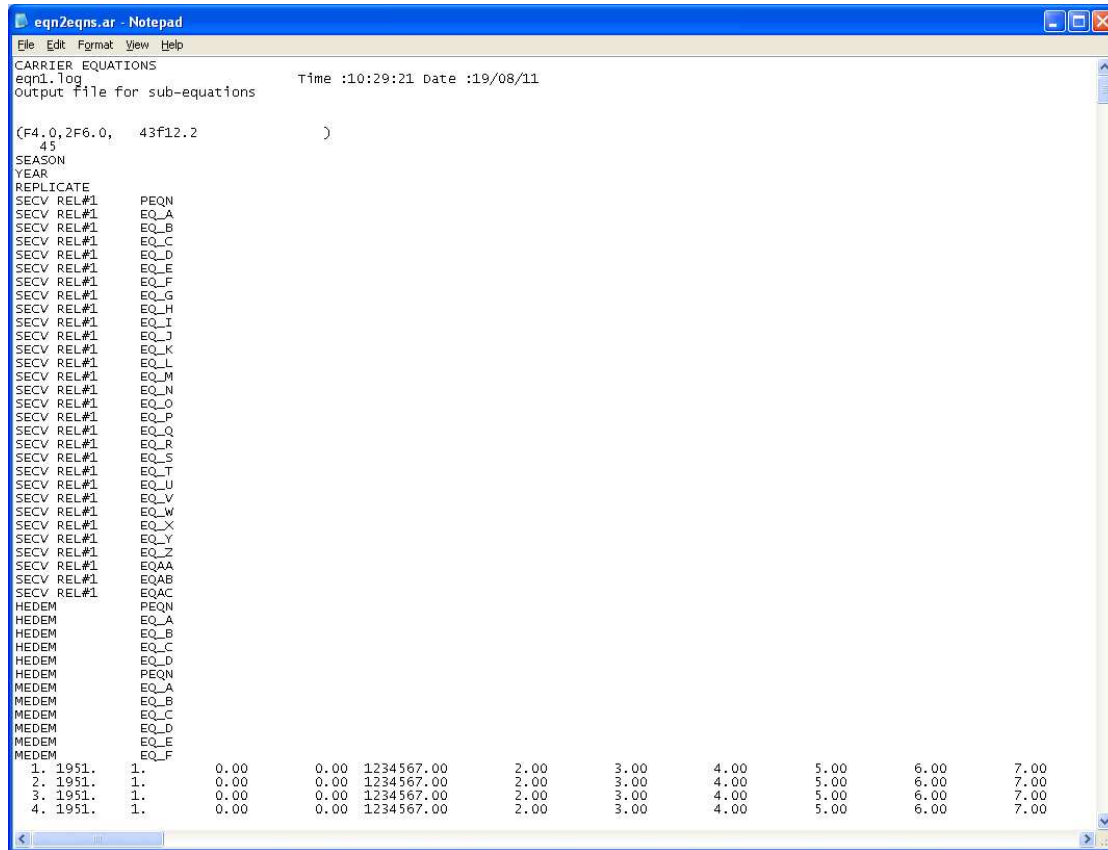


Figure 7-8 Sample Sub-equation Output File

Note that it is possible for the primary sub-equation result to be different to the final capacity of a carrier even if the capacity transformation table is a direct translation. This may be indicative of the model not reaching a stable solution in some or all time steps. Users are advised to check the results to ensure the equation functionality is working as intended.

Chapter 8

8 UTILITIES

This chapter discusses the REALM utilities, which can be used to perform basic processing of REALM format input and output files. They can be run by selecting the appropriate menu item from the REALM Program Manager (Figure 4-1) by clicking on *Utilities*.

8.1 REALM PLOTTING

REALM Plotting utility can be used to display contents of REALM format file inputs and outputs in graphical form. Data from any combination of REALM input and output files can be plotted. This utility is designed as an investigative tool to display and compare data.

The REALM Plotting utility performs three main functions, namely,


- Time series plotting,
- Scatter plotting, and
- Data transformation.

REALM Plotting is designed to plot or transform data of a single replicate. Files with multiple replicate data cannot be plotted or transformed. Therefore, it is necessary to use Replicate Analysis (see Section 8.1) first to extract the required replicate of data from the multiple replicate file, save it under a different filename and then use the Plot functions.

Furthermore, this utility plots or transforms the whole data set of the selected items and does not allow the user to plot or transform subsets of data of those items.

8.1.1 TO OPEN REALM PLOTTING:

Click on *Plot* item (*Utilities::Plot*) in the *Utilities* menu (Figure 8-1) **or**

Click on the  'Plotting routines' button on the toolbar of the REALM Program Manager (Figure 4-1).

This displays the REALM Plotting window (Figure 8-2), which also shows the project directory in the left compartment of the status bar. Note the most of the buttons on the toolbar are initially inactive. The relevant buttons will be activated when files are opened and plotted.

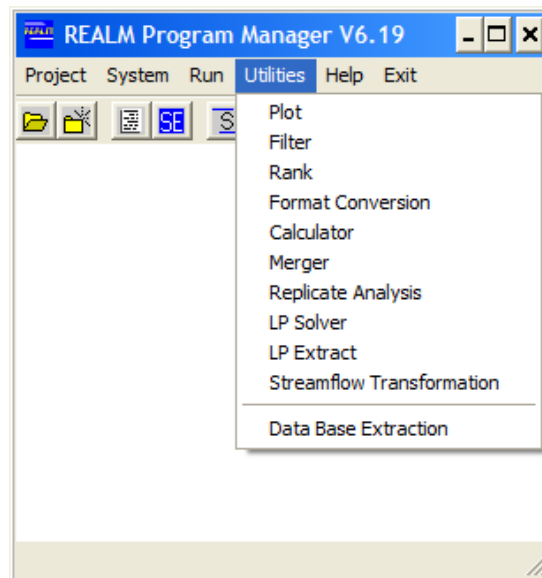


Figure 8-1 Utility Menu Listing of REALM Program Manager

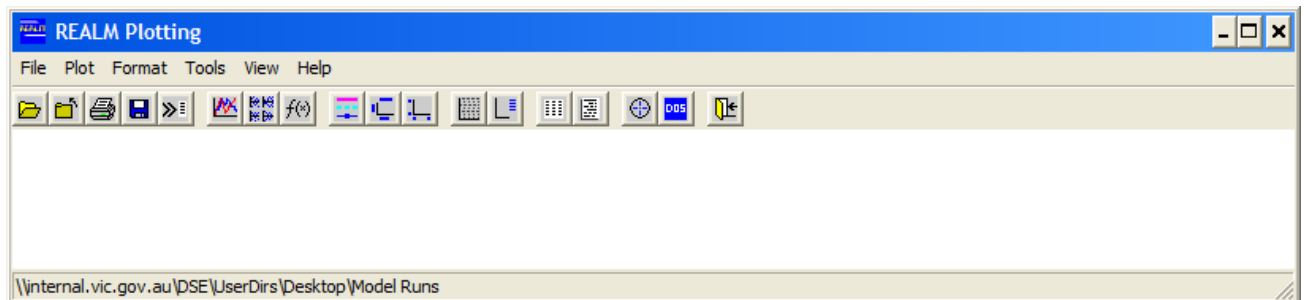



Figure 8-2 REALM Plotting Window

8.1.2 TO OPEN/CLOSE DATA FILES:

Click on *File::Open* menu item of the REALM Plotting window to load data files for plotting and transformation **or**

Click on the  'Open REALM format files' button on the toolbar.

This displays the "Open files" dialog box (Figure 8-3).


Manually enter the name of the data file with its appropriate path **or**

Use the browser button next to the 'File 1' field to locate the required file. Click on the required file and hit **Open**.

Up to four files may be opened. Figure 8-3 shows an example with two files entered.



Click on **OK**, and return to the REALM Plotting window (Figure 8-2).

Clicking on **Cancel** returns the user to the REALM Plotting window without the files being accepted.

It is possible to overwrite the files already selected in dialog box in Figure 8-4. Click on the  'Browser' button adjacent to the file which is no longer required, browse

through to the required directory and select the required file. This file will replace the original file.

The menu items of the middle partition under *File* menu will appear once the plots are created from time series and scatter plotting.

Once the user has clicked on **OK** on the “Open Files” dialog box (Figure 8-3), the *Close* menu item in the *File* menu, as well as the  ‘Close’ button on the toolbar, becomes active. Clicking on *File::Close* menu item or the  ‘Close’ button displays Figure 8-4 and allows the user to selectively close individual files that are no longer required for plotting and data transformation. By clicking on the **Close** button corresponding to the file, the user eliminates the file from the plotting dialog box.

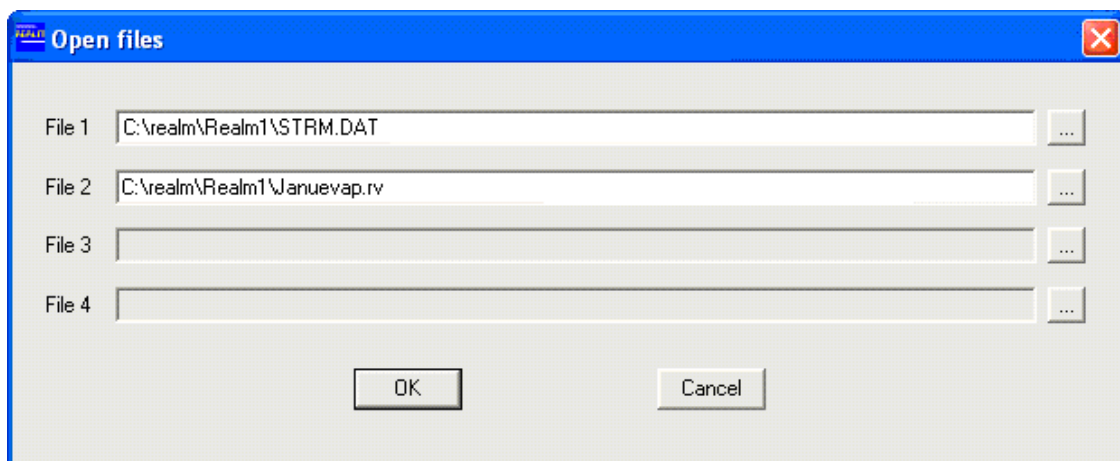


Figure 8-3 Open Files Dialog Box with two files specified

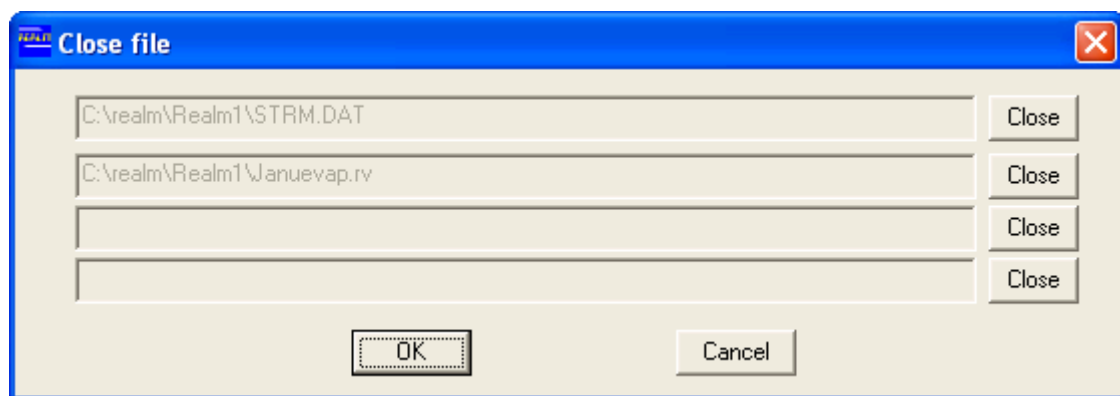





Figure 8-4 Close File Dialog Box


Once the files have been selected, the  ‘Do time series plot’ button,  ‘Do scatter plot’ button and the  ‘Transform/create new variables’ button on the toolbar become active (Figure 8-2).

8.1.3 TIME SERIES PLOTTING

The user can graph any combination of variables from the specific files in the ‘Select file’ list, and they can be plotted in the main plot area (on the bottom panel) or in the top panel.

To plot a time series:

Click on the *Plot::Time series* menu item **or**

Click on the  'Do time series plot' button.

The "Time Series Plot" dialog box is displayed (Figure 8-5).

Select the relevant file from the 'Select file' drop down list, which contains the file(s) selected by the user. By selecting the relevant file, the user is able see the variables included in this file in the 'Select variable' compartment.

Click on the variable to be plotted in the 'Select variable' compartment.

Click on the **Add →** button to move the variable from 'Select variable' compartment to either the 'Main plot area' or 'Top panel'. Repeat for all of the variables to appear on the graph.

The selection of the variables SEASON and YEAR are not required, since they are considered automatically in the time series plot.

Selecting variables only in the main panel will result in the plot in the main panel alone, whereas selecting variables only in the top panel will result in the plot in the top panel. Selecting variables in both top and main panels will result in plots in both top and main panels.

The **← Remove** button returns the selected variable back to the 'Select variable' compartment, under its file.

The **Reset All** button empties (or resets) the entries in both the 'Main plot area' and the 'Top panel'.

The 'Include file descriptor in plot variable names' check box allows the user to add the data filename connected to the variable in the plot itself. If the box is ticked, then the name of the file connected to that particular variable is included in the time series plot on the vertical axis.

The **Find...** button in the centre of the dialog box allows the user to quickly search for the required variable when there is a large list of variables. When the **Find...** button is clicked, the "Text Search" dialog box appears. Enter the text string contained in the name of the variable (at least the first few letters/characters of the variable) to search for the variable. Click on **OK** to return to the "Time Series Plot" dialog box (Figure 8-5), highlighting the variables with the relevant text string. Note that the search string is not case sensitive. Sometimes, it may be necessary to find the other variable names in the same data file with the same text string. The user can then click on the **Find Again** button in Figure 8-5 to continue the search, thus highlighting a different variable with the same text string.

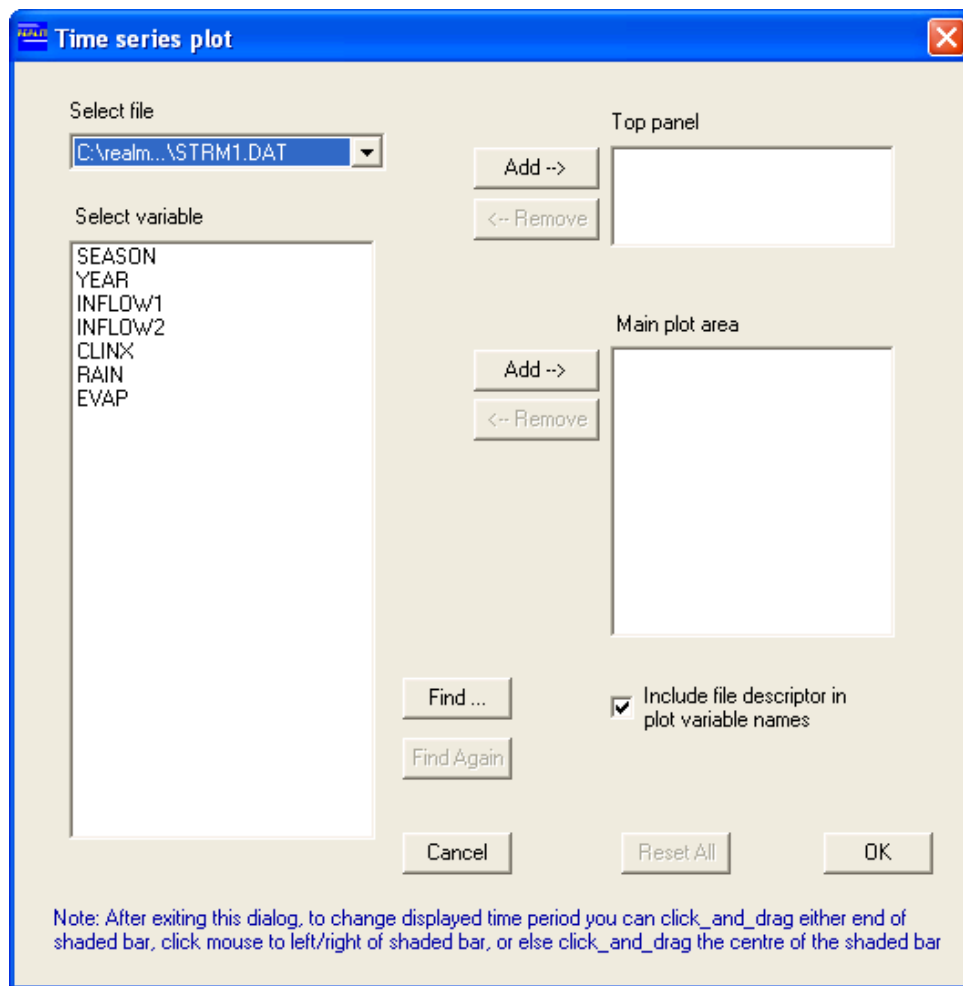


Figure 8-5 Time Series Plot Dialog Box

Click on **OK** in "Time Series Plot" dialog box (Figure 8-5) to produce the time series graph, with the selected variables shown as separate coloured lines (Figure 8-6).

Clicking on **Cancel** returns the user to the REALM Plotting window without generating a graph.

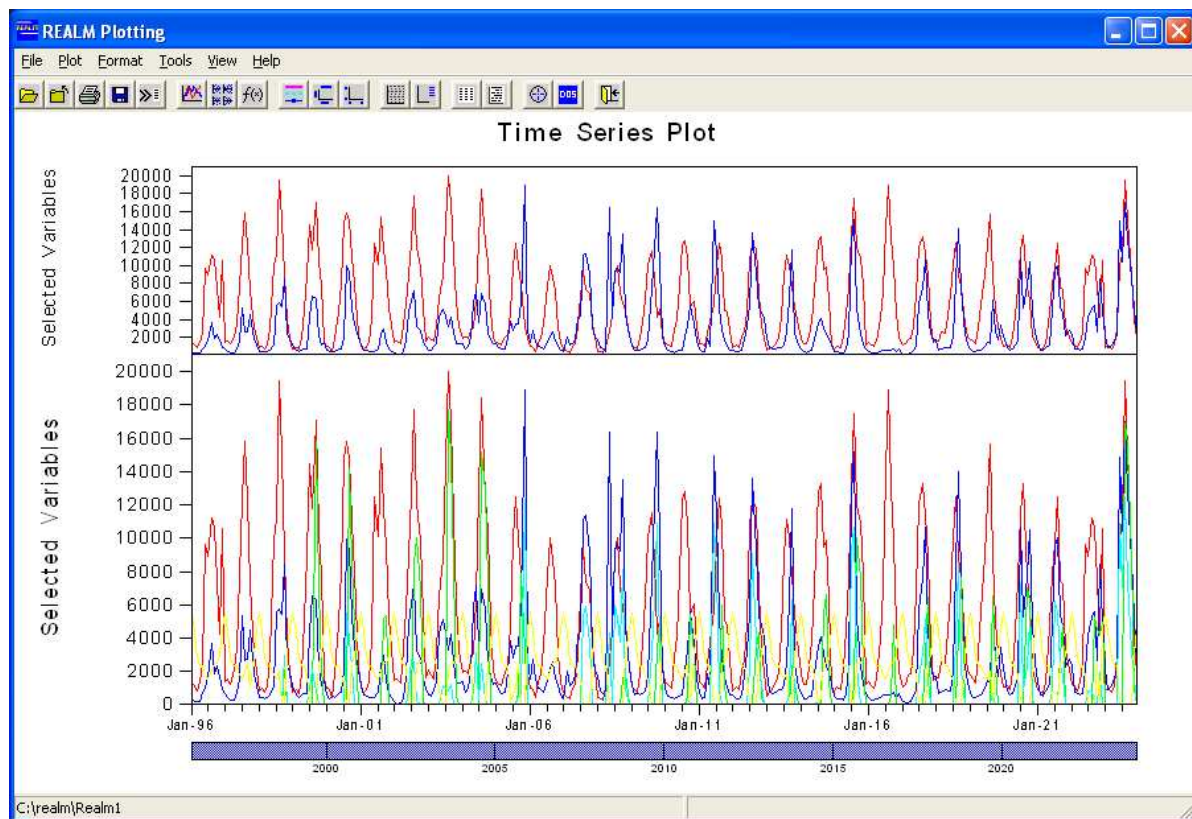


Figure 8-6 Example of a Time Series Plot

The shaded bar beneath the graph allows the user to zoom into the graph and observe the graph within a set domain. By clicking on the mouse at either edge or both edges of the blue bar and dragging it to the required domain, the graph zooms into the required domain. The length of the domain can be maintained and moved to another part of the graph by clicking on over the remaining blue bar and dragging it to the new domain.

Once a time series plot has been created, all the buttons in the REALM Plotting window become active. The *Print*, *Save* and *Export* items in the middle partition of *File menu* become active, as do their respective buttons on the toolbar (🖨️, 💾 and ➡️ buttons).

8.1.3.1 FORMAT DATA SERIES

Format data series allows the user to alter the appearance of the lines of the variables represented in the plot. By clicking on either the *Format::Data series* menu item, or on the *Format data series* button on the toolbar, the user is presented with the “Format Time Series Data” dialog box (Figure 8-7). Each of the variables selected is shown in the left-most column. Note that the first eight characters of the filename (in this example, ‘STRM1.DA’ and ‘Januinfw’) prefix each series name. This is because the check box ‘Include file descriptor in plot variable names’ was ticked when the plot was created (Figure 8-5). The next three columns show the Colour, Marker type and Style. By clicking on either of the top-down arrows, the user is able to choose which colour represents each variable, the type of marker used to represent the variable, as well as the style of the marker. Clicking on **OK** accepts the changes and shows them in the time series plot (Figure 8-6). Clicking on **Cancel** returns the user to Figure 8-6 without accepting the changes (if any).

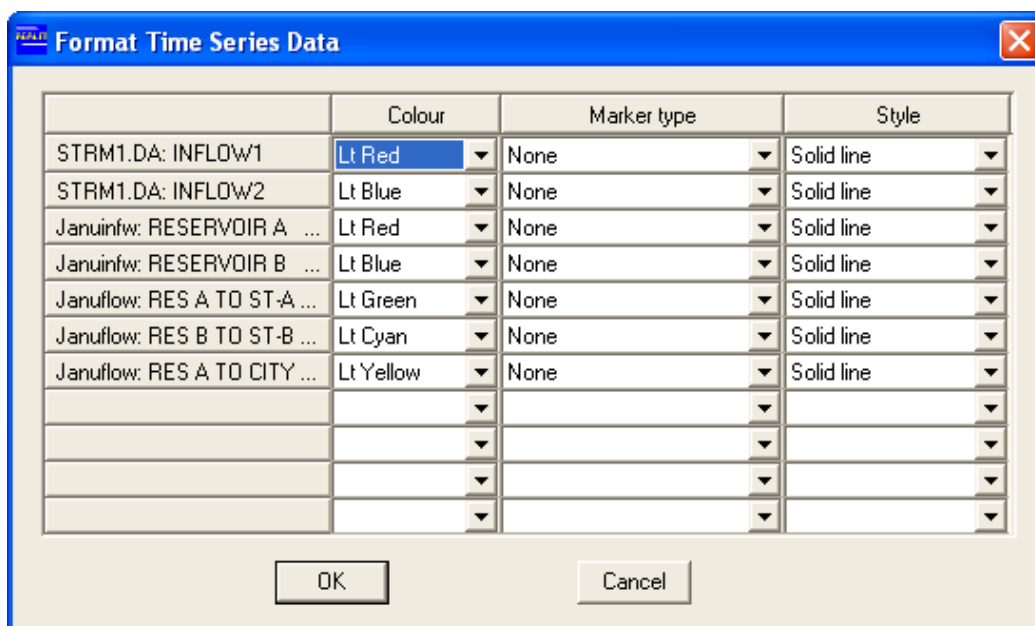


Figure 8-7 Format Time Series Data Dialog Box

8.1.3.2 FORMAT PLOT TITLES

Format plot titles allows the user to alter the titles appearing on the plot. By either selecting the *Format::Titles* menu item or clicking on the *Format plot titles'* button on the toolbar, the user is presented with the "Format Time Series Titles" dialog box (Figure 8-8). The first field allows the user to alter the overall title of the plot, and titles of main panel and top panel y-axes. By clicking on the required field, the user is able to alter the titles of the plot. Clicking on **OK** accepts the changes and shows them on the time series plot (Figure 8-6). Clicking on **Cancel** returns the user to Figure 8-6 without accepting the changes (if any).

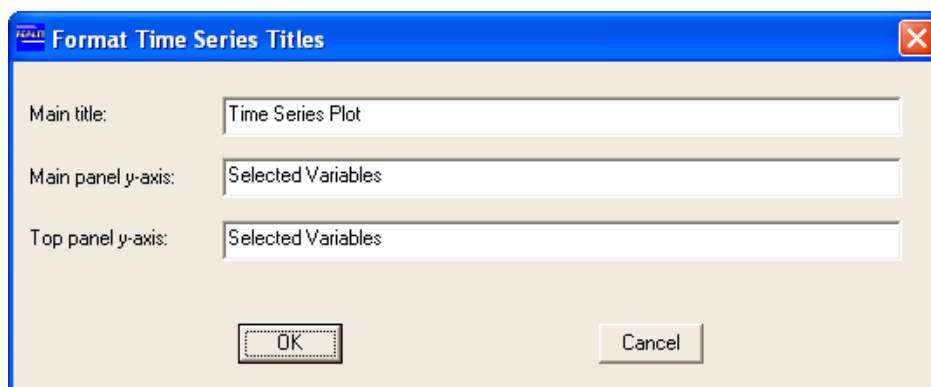


Figure 8-8 Format Plot Titles Dialog Box

8.1.3.3 FORMAT PLOT AXES

Format plot axes allows the user to alter the scale of the plot axes. By either selecting the *Format::Axes* menu item or clicking on the *Format plot axes'* button on the toolbar, the user is presented with the "Format Time Series Plot Axes" dialog box (Figure 8-9). The top partition allows the user to alter the domain (i.e. start season,

start year, end season and end year) for which the variables are plotted. The result is similar to the zooming facility described in Section 8.1.3.

The block “Main Panel Y-Axis” offers the user two possibilities: (1) allow REALM to automatically set the range of the main panel; or (2) manually select the range of the main panel. Ticking the check boxes under the label “Auto” for ‘Minimum’ and ‘Maximum’ will automatically set the range of the y-axis. If these check boxes are blank, the fields ‘Maximum’ and ‘Minimum’ are activated, allowing the user to manually type in the required range. The user may also wish to have a logarithmic scale for the y-axis, particularly if the range is very large. By ticking the ‘Logarithmic scale’ check box, the user selects to have the y-axis with a logarithmic scale (base 10).

The ‘Top Panel Y-Axis’ block has the same operations as that of the main panel, except for one difference: the user is able to select the height of the top panel as a percentage of the total height of the plot. By clicking on the up/down arrows, the user can set the required ratio to the total plot.

Clicking on **OK** in Figure 8-9 accepts the changes and shows them on the time series plot (Figure 8-6). Clicking on **Cancel** returns the user to the same dialog box, but without accepting the changes (if any).

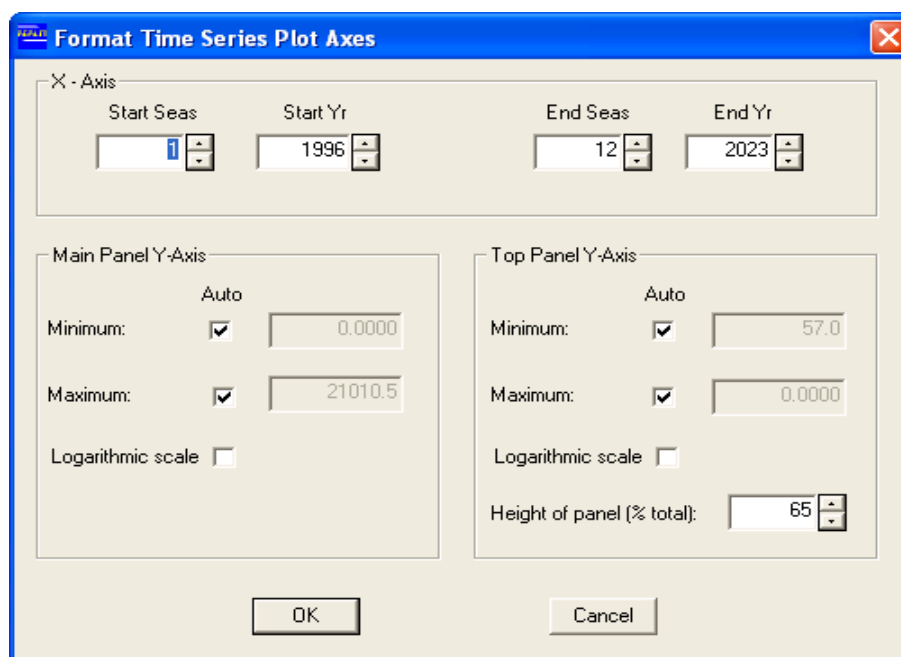




Figure 8-9 Format Time Series Plot Axes Dialog Box

If the variables have been selected for plotting only in the main panel, then the ‘Top Panel Y-Axis’ block is inactive. Similarly if the variables have been selected only in the top panel, then the ‘Main Panel Y-Axis’ block is inactive.

8.1.3.4 TOGGLE GRATICULES ON/OFF

Toggle graticules on/off allows the user to make use of the graticules in order to read the plot easily. By either selecting the *Format::Graticules* menu item or clicking on the  ‘Toggle graticules on/off’ button on the toolbar, the user is presented with the

plot with graticules (Figure 8-10). Clicking on the  'Toggle graticules on/off' button again removes the graticules from the graph.

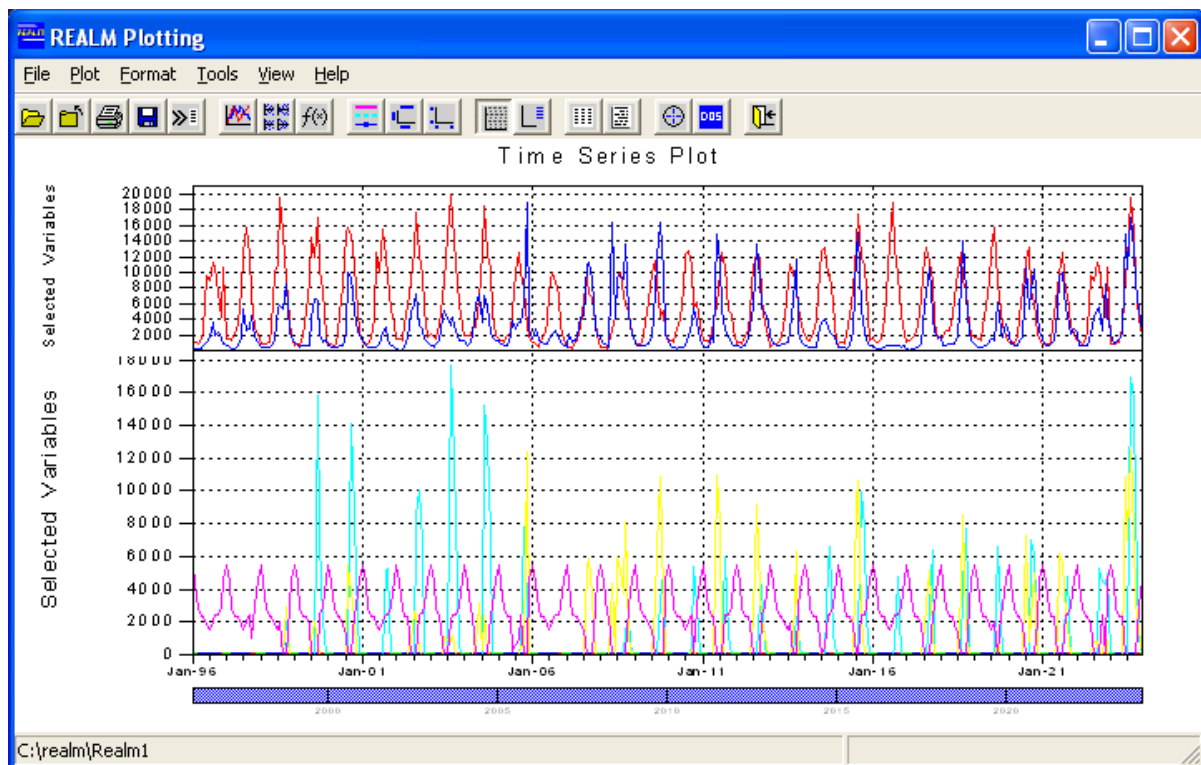





Figure 8-10 Example of a Time Series Plot with Graticules

8.1.3.5 TOGGLE LEGEND ON/OFF

Toggle legend on/off allows the user to display a legend, as well as alter the names of the variables appearing in the legend. By either selecting the *Format::Legend* menu item or clicking on the  'Toggle legend on/off' button on the toolbar, the user is presented with the "Format Legend" dialog box (Figure 8-11). Ticking the 'Display Legend' check box displays the legend for the plot on the right-hand side of the graph, while the 'Series Label' allows the user to alter the labels of the variables presented on the plot. Clicking on **OK** in Figure 8-11 accepts the changes and applies them on the time series plot (Figure 8-6). Clicking on **Cancel** returns the user to the same plot, but without accepting the changes (if any).

8.1.3.6 VIEW DISPLAYED PLOT DATA

View displayed plot data allows the user to view the data used in the creation of the plot. By either selecting the *View::Displayed data* menu item or clicking on the  'View displayed plot data' button on the toolbar, the user is presented with the data in tabular form as shown in Figure 8-12. This operation has used REALM Text Editor/ File Viewer. The Text Editor (Section 4.3.2) can also be accessed through *System::Text Editor* in REALM Program Manager (Figure 4-1). Clicking on the  'Close Window' button on title bar or selecting *File::Exit* menu item takes the user back to the time series plot (Figure 8-6).

If the user has used the zoom in facility (Section 8.1.3) or changed the format axes length in x-axis (Section 8.1.3.3) to shows part of the plot, then the data relevant to only this part of the plot is shown in Figure 8-12.

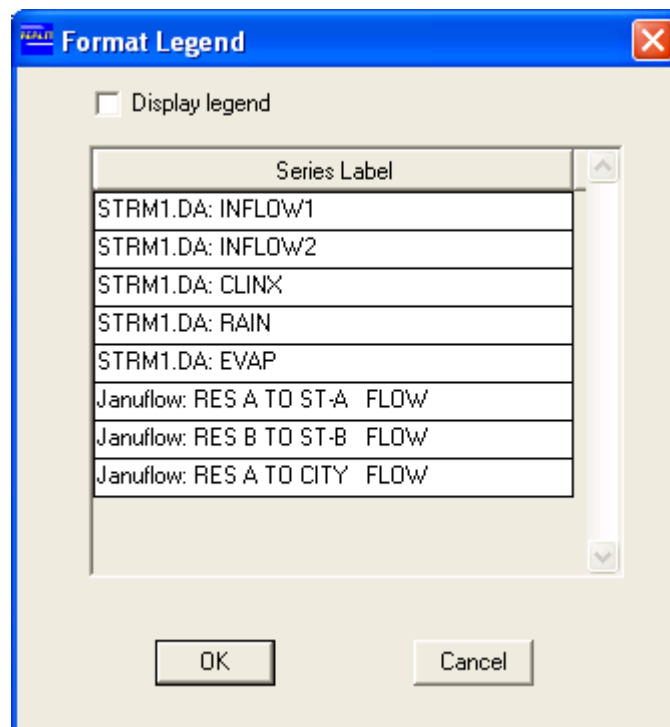





Figure 8-11 Format Legend Dialog Box

8.1.3.7 VIEW DATA FILE

View data file allows the user to look at the data files and the data contained in these files of the project directory. The user is also able to go to any other directory, and look at a file and contents, using the standard browsing facility. Click on either the *View::File contents* menu item or the  'View data file' button, then browse to the required file and open it. Figure 8-12 is an example of a plot data file. Clicking on **Cancel** takes the user also to the Text Editor (i.e. file viewer) but with empty contents. Exit from the Text Editor to return to the Plotting window.

8.1.3.8 DIGITISE DATA ON PLOT

Digitise data on the plot allows the user to view data corresponding to particular SEASON/YEAR by pointing the mouse to the required point on the plot. By either selecting the *Tools::Digitise points* menu item or clicking on the  'Digitise data on plot' button on the toolbar, the user is presented with the data as in Figure 8-13 of all plots corresponding to the SEASON/YEAR the user specified by locating with the mouse pointer. As you move the mouse pointer from one location to another horizontally, the data shown in this dialog box change accordingly. Clicking on the  'Digitise data on plot' button again, removes the data window from Figure 8-6.

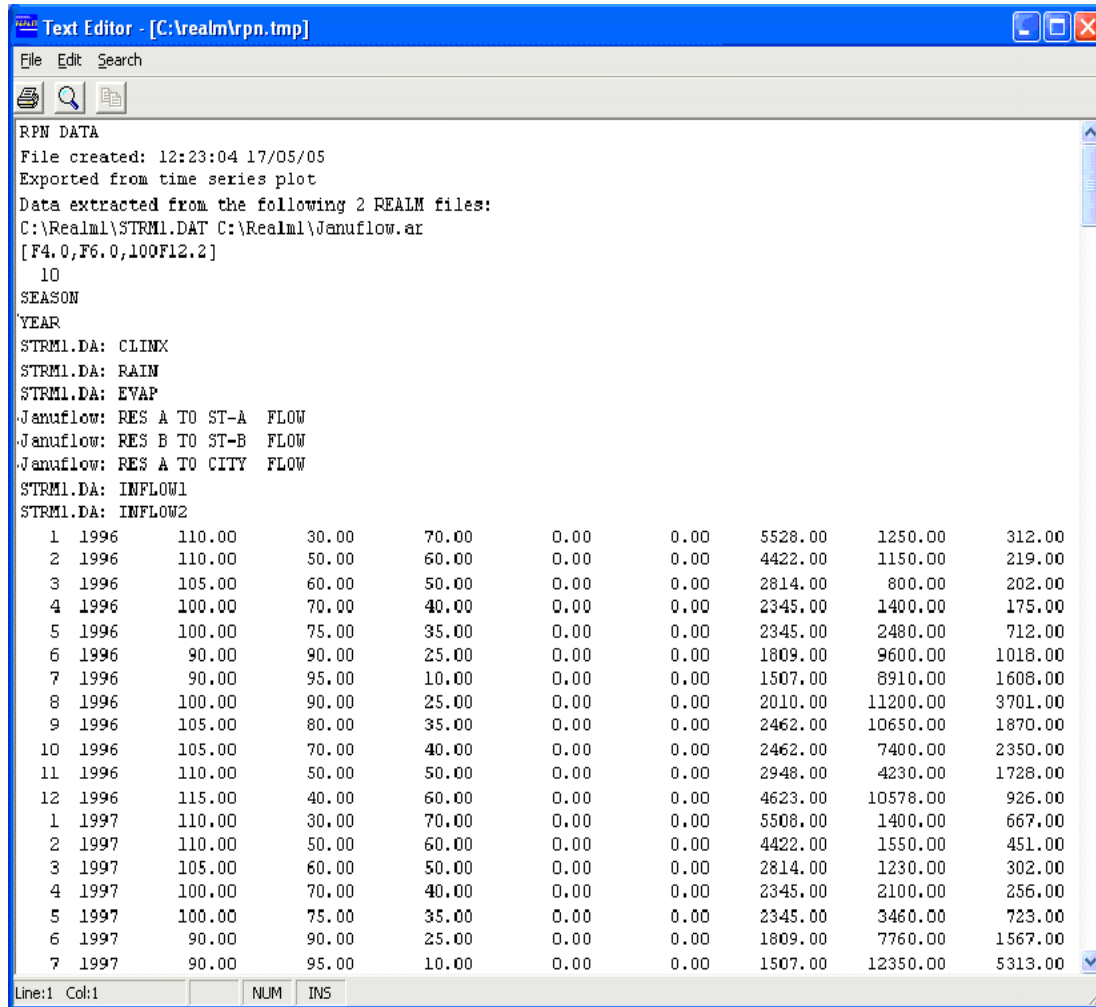


Figure 8-12 Dialog Box Displaying Plot Data

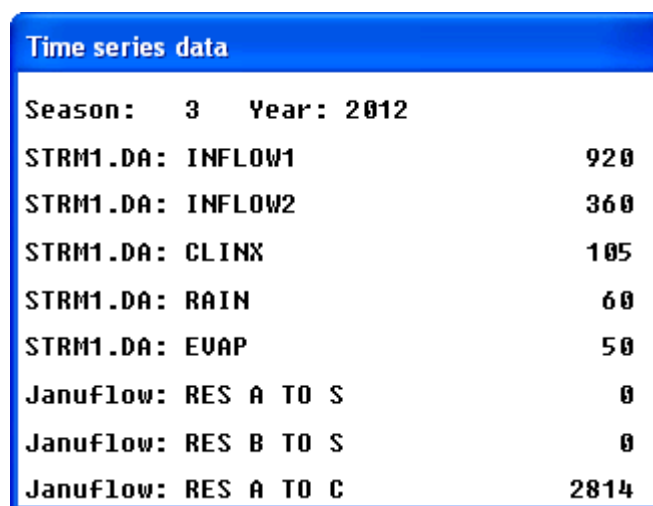



Figure 8-13 Digitise Data on Plot Box

8.1.4 SCATTER PLOTTING

Once the required REALM format files are loaded, the time series plotting, scatter plotting and data transformation menu items, as well as their respective buttons, become active, as shown in Figure 8-2. By selecting the *Plot::Scatter plot* menu item or clicking on the  'Do Scatterplot' button of REALM Plotting window (Figure 8-2), the user is presented with the "Scatter Plot" dialog box (Figure 8-14).

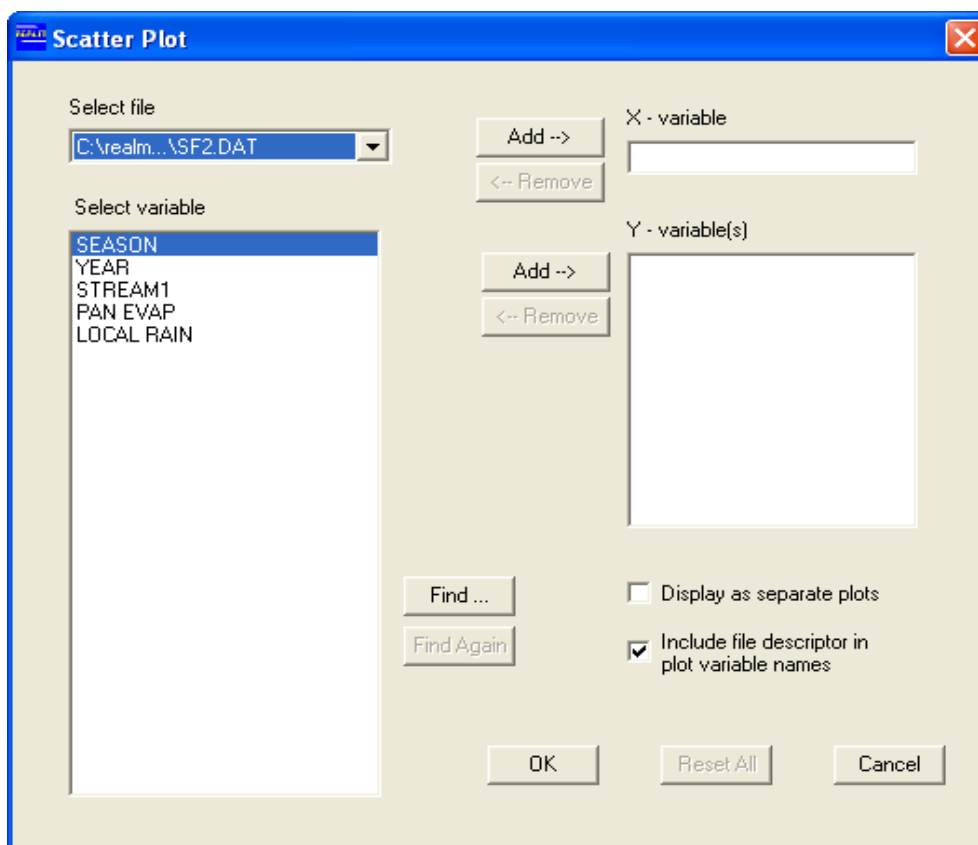


Figure 8-14 Scatter Plot Configuration Dialog Box

The 'Select file' combo box contains the file(s) selected by the user (Section 8.1.2). When a file is selected, all the variables in that file will be listed in the list box with the heading 'Select variable'. The user can select the required variable(s) to be plotted one against another. Highlight the variable and click on the **Add →** button, to move the variable from the 'Select variable' list box to either the X-variable or the Y-variable list. The **<-- Remove** button returns the selected variable to the 'Select variable' list. When a variable is returned to the 'Select variable' list, the 'Select file' field will display the file from which that variable was selected. Note that only one variable can be plotted on the x-axis.


The user is able to plot the variables in one plot or separate plots by ticking the 'Display as separate plots' check box. The 'Include file descriptor in plot variable names' check box allows the user to select whether to show the data filename connected to the variables in the plot itself. If this box is ticked, then the variable names will appear attached with the name of the source file in the scatter plot on the vertical axis.

The **Find** button in the centre of the dialog box allows the user to quickly search for the required variable when there is a large amount of variables listed in the 'Select

variable' list. When the **Find** button is clicked, the "Text Search" dialog box appears. Enter the text (at least the first few letters/characters of the variable) to search in the list of variable names. Clicking on **OK** takes the user back to the "Scatter Plot" dialog box (Figure 8-14), now highlighting the variable with the searched text in its name. Sometimes, it may be necessary to find the other variables of the same data file with the same search text. Click on the **Find Again** button of Figure 8-14 (which becomes active) to continue searching, thus highlighting a different variable (if another match is found).

Clicking the **OK** button in the "Scatter Plot" configuration dialog box (Figure 8-14) will produce the scatter plot. Selected variables appear as points in different colours, styles and shapes, as shown in Figure 8-15. In this figure, only a single scatter plot is shown for all variables. Figure 8-16 shows separate scatter plots with multiple variables because the '*Display as separate plots*' check box in Figure 8-14 was ticked. Once the variables have been selected by the user in Figure 8-14, the **Reset All** button becomes active. Click on the **Reset All** button when '*X-variable*' and '*Y-variable*' lists need to be empty (or reset). Clicking on **Cancel** returns the user to the REALM Plotting window without generating a graph.

8.1.4.1 FORMAT SCATTER PLOT DATA SERIES

Format Scatter Plot Data Series allows the user to alter the appearance of the lines of the variables in the plot. By either selecting the *Format::Data series* menu item or clicking on the  '*Format data series*' button on the toolbar in the REALM Plotting window (Figure 8-2), the user is presented with the "Format Scatter Plot Data Series" dialog box (Figure 8-17). Each of the variables selected is shown in the left-most column. Note that the variable name is prefixed with the first eight characters of its filename in the descriptions of the variables. This is the result of ticking the check box '*Include the file descriptor in the plot variable names*' in Figure 8-14.

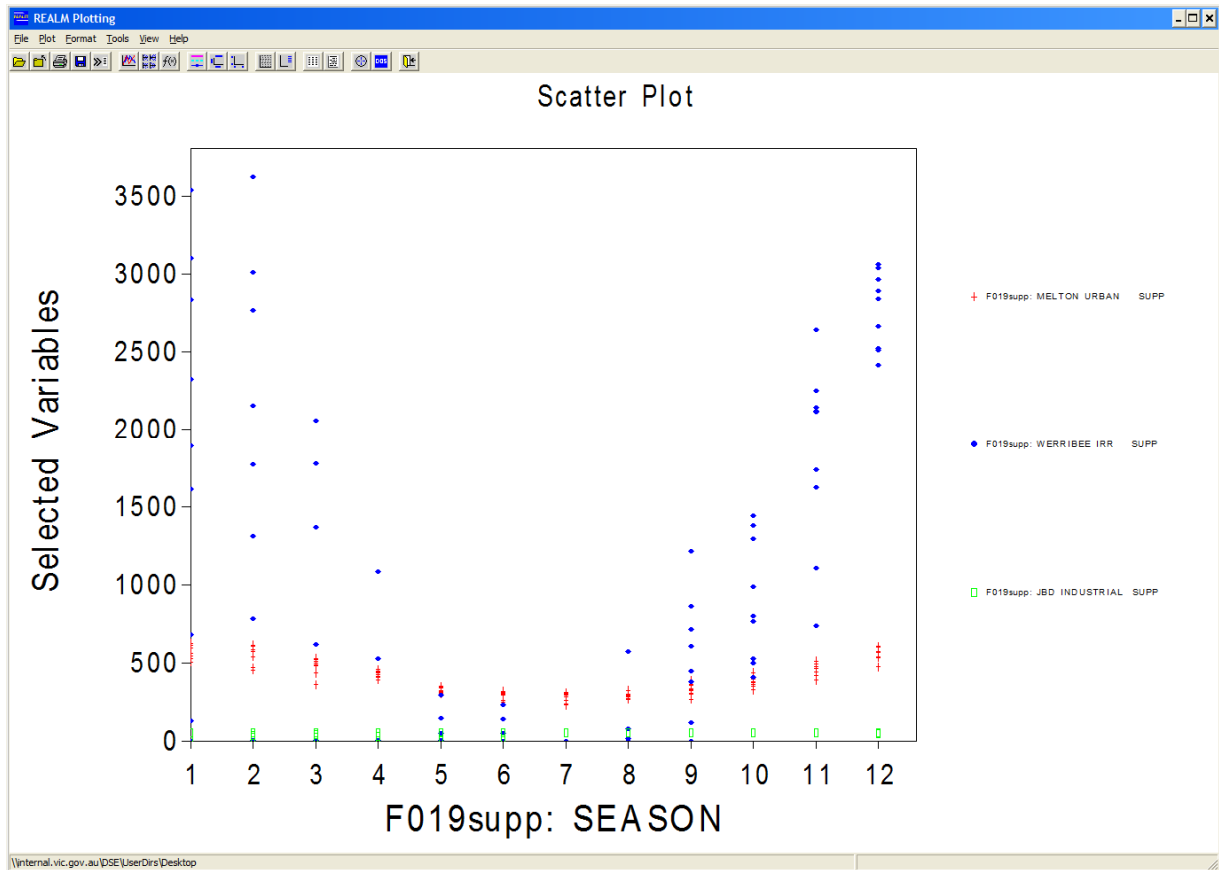


Figure 8-15 Single Scatter Plot with Multiple Variables and Legend Displayed

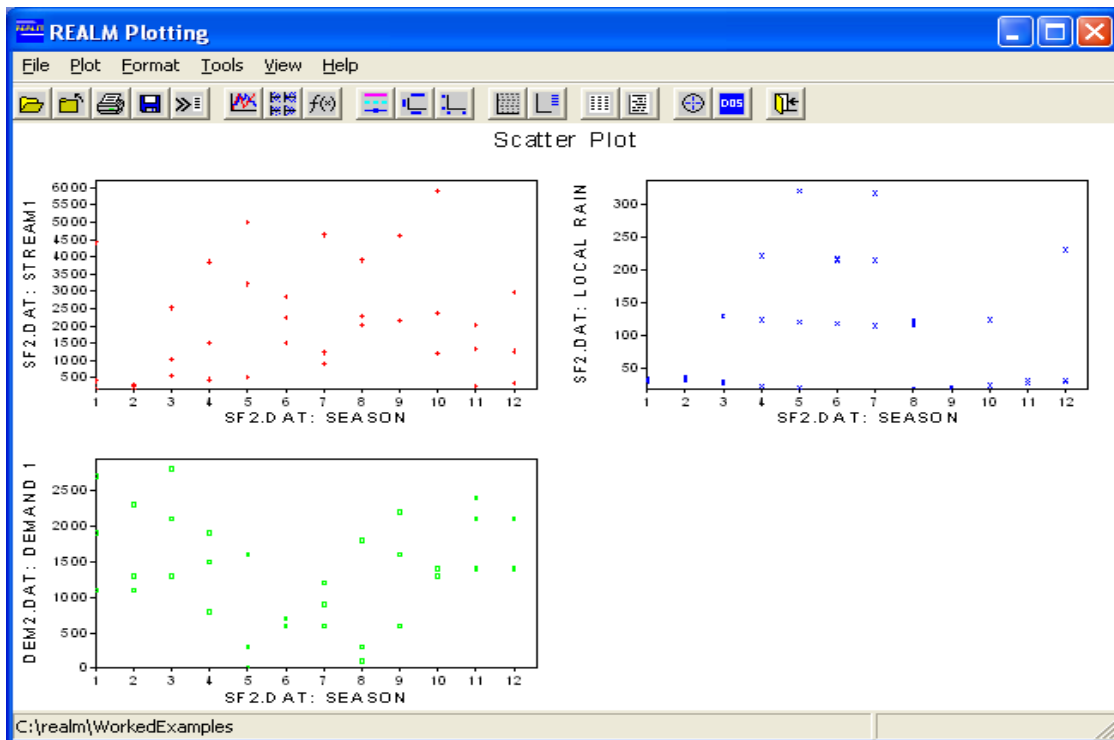


Figure 8-16 Separate Scatter Plots with Multiple Variables

In the “Format Scatter Plot Data Series” dialog box (Figure 8-17) there are two columns headed ‘Colour’ and ‘Marker type’ respectively. By selecting from the relevant drop down list, the user can specify the colour and the marker type to represent each variable separately. Click on the **OK** button to accept the changes and show them in the scatter plot. Click on **Cancel** to return to the scatter plot without applying the changes (if any).

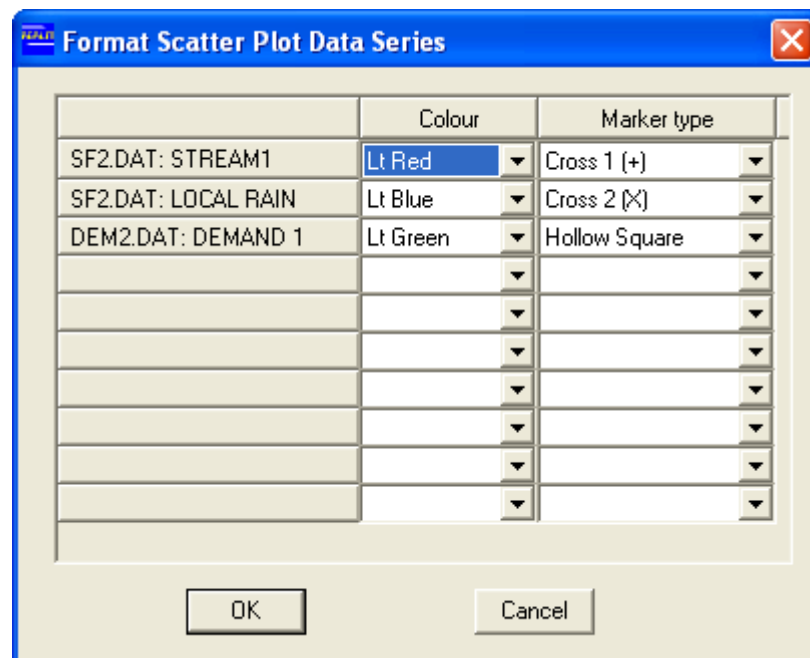


Figure 8-17 Format Scatter Plot Data Series Dialog Box

8.1.4.2 FORMAT PLOT TITLES

Format plot titles allows the user to alter the titles appearing on the plot. By either selecting the *Format::Titles* menu item or clicking on the 'Format plot titles' button on the toolbar in the REALM Plotting window (Figure 8-2), the user is presented with the “Format Scatter Plot Titles” dialog box (Figure 8-18). The text fields labelled ‘Main title’, ‘x-axis’, and ‘y-axis’ allow the user to alter the overall title for the plot, the x-axis title, and the y-axis title(s) respectively. Clicking on **OK** accepts the changes and displays them on the scatter plot. Click on **Cancel** to return to the scatter plot without applying the changes (if any).

8.1.4.3 FORMAT PLOT AXES

Format plot axes allows the user to alter the domain and/or range of the plot(s). By either selecting the *Format::Axes* menu item or clicking on the 'Format plot axes' button on the toolbar in the REALM Plotting window (Figure 8-2), the user is presented with the “Format Scatter Plot Axes” dialog box (Figure 8-19). There are two tabs labelled “X-Axes” and “Y-Axes”.

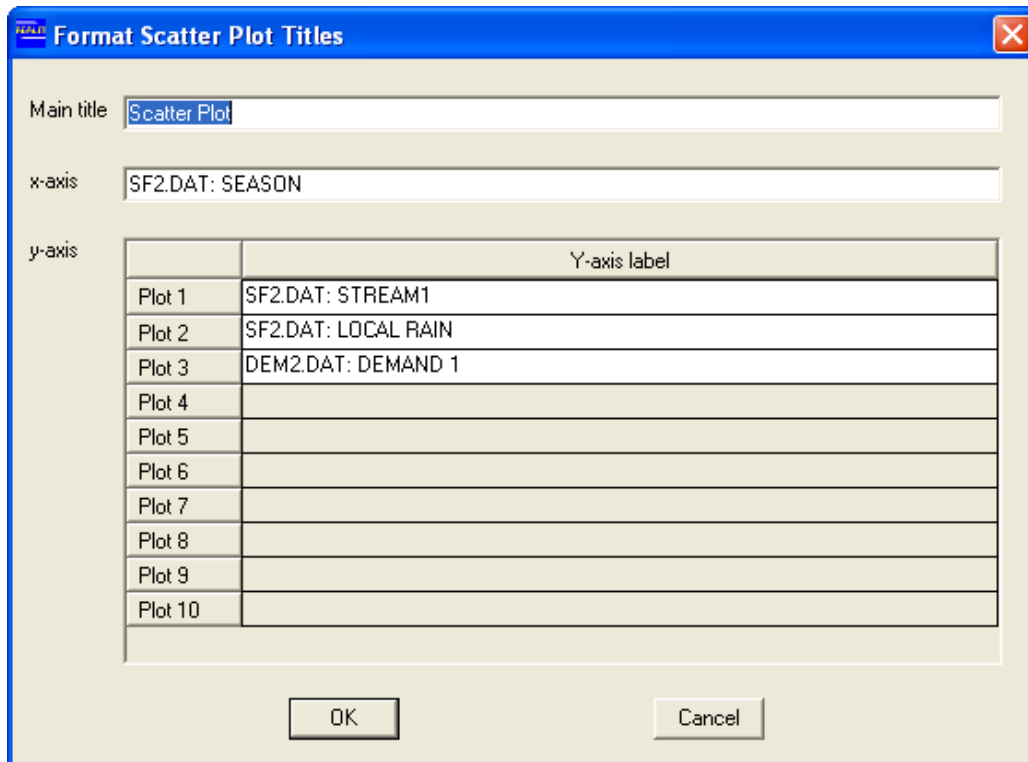


Figure 8-18 Format Scatter Plot Titles Dialog Box

The “X-Axes” tab allows the user to alter the domain for each scatterplot. Click on the relevant cells in the columns headed ‘Minimum’ and ‘Maximum’ to manually set the scale for the x-axis. In the same way, the “Y-Axes” tab allows the user to manually specify the range for each scatterplot.

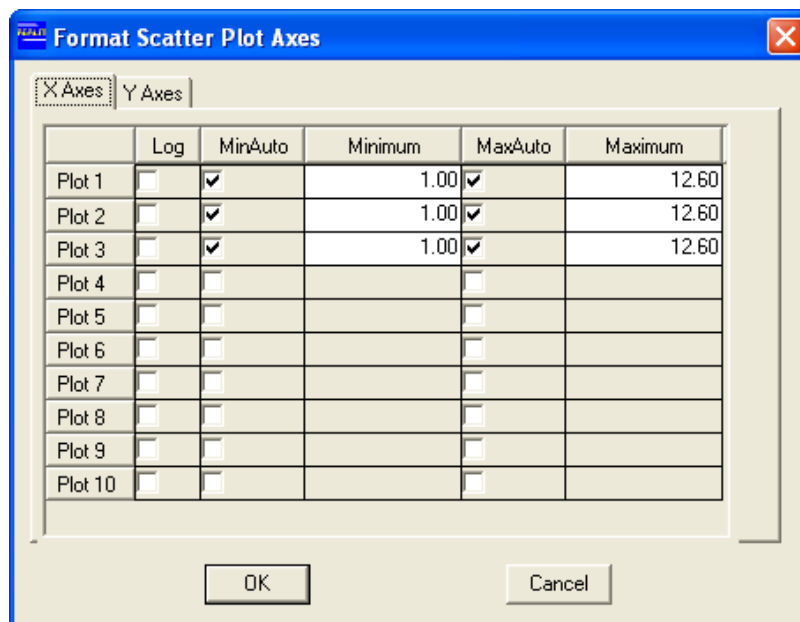




Figure 8-19 Format Scatter Plot Axes Dialog Box


Ticking the check boxes in the columns ‘MinAuto’ or ‘MaxAuto’ results in the domain and/or range being set automatically. Un-checking the check boxes results in the

minimum and maximum fields being activated with their respective values, which can be altered manually. The user may also wish to have a logarithmic scale for the axes, particularly if the range of values is very large. By clicking on the check box under the 'Log' heading, the user selects to have the axes with a logarithmic scale (base 10). Clicking on **OK** accepts the changes and displays them on the scatter plot. Clicking on **Cancel** returns the user to scatter plot without accepting the changes (if any).

8.1.4.4 TOGGLE GRATICULES ON/OFF

Toggle Graticules On/Off allows the user to make use of the graticules in order to read the plot easily. By either selecting the *Format::Graticules* menu item or clicking on the  'Toggle graticules on/off' button on the toolbar in the REALM Plotting window (Figure 8-2), the user is presented with the scatter plot with graticules (Figure 8-20). Clicking on the  'Toggle graticules on/off' button again removes the graticules from the graph.

8.1.4.5 TOGGLE LEGEND ON/OFF

Toggle Legend On/Off allows the user to display a legend, as well as alter the names of the variables on the plot. By either selecting the *Format::Legend* menu item or clicking on the  'Toggle legend on/off' button on the toolbar in the REALM Plotting window, the user is presented with the "Format Legend" dialog box (Figure 8-21).

Ticking the check box 'Display Legend' displays the legend for the plot on the right-hand side of the scatter plot (Figure 8-15), while the 'Series Label' allows the user to alter the name of the variables presented in the plot. In Figure 8-15, the first eight characters of the filename (in this example, 'F019SUPP') prefix each series name in the legend. This is because the check box 'Include file descriptor in plot variable names' was ticked when the scatter plot was created (Figure 8-14). Clicking on **OK** accepts the changes and shows them on the scatter plot. Clicking on **Cancel** returns the user to the scatter plots (Figure 8-15), without accepting the changes (if any). Note that a legend cannot be displayed when the check box 'Display as separate plots' is ticked.

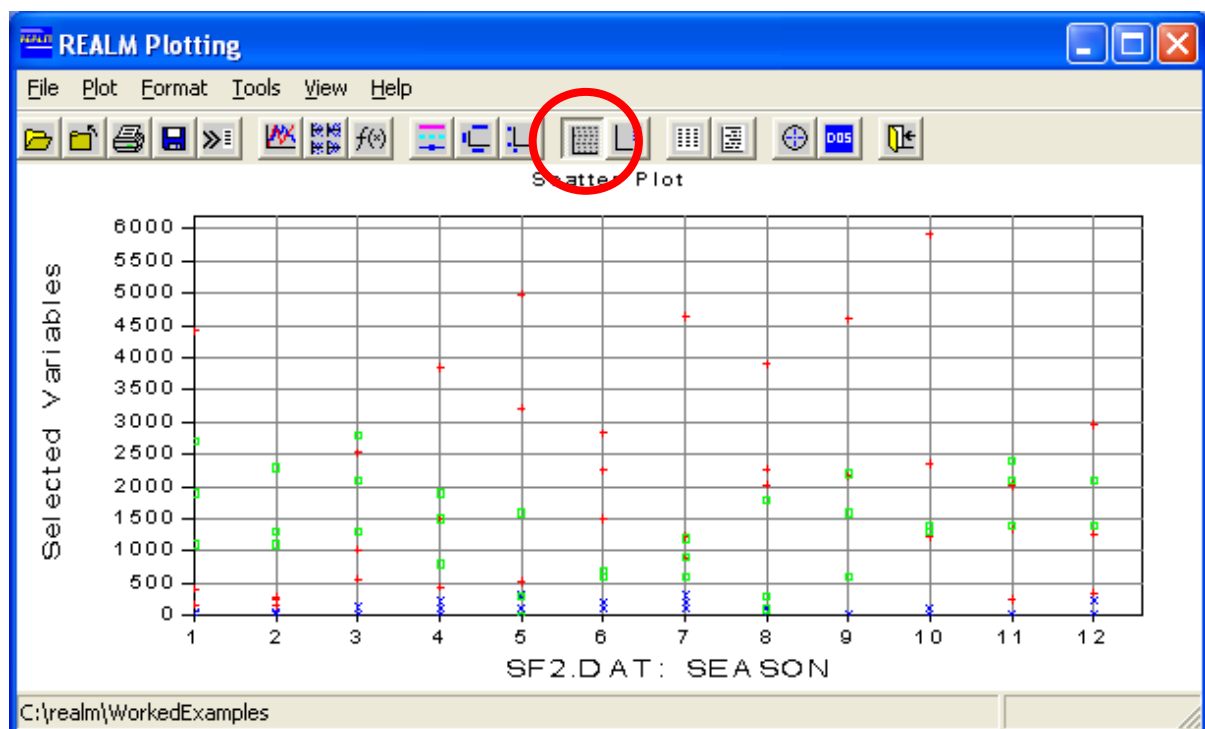


Figure 8-20 Example of a Scatter Plot with Graticules

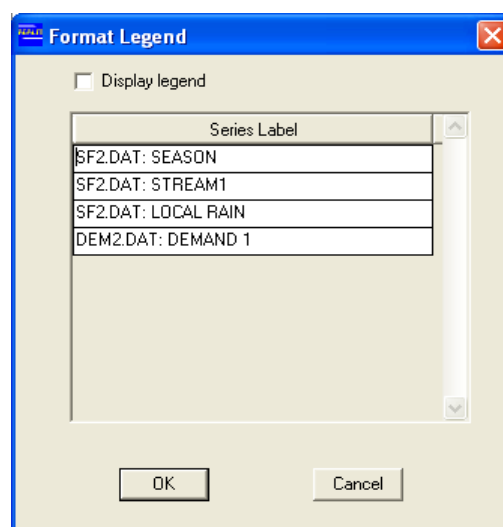


Figure 8-21 Format Legend Dialog Box

8.1.4.6 VIEW DISPLAYED PLOT DATA


View displayed plot data allows the user to view the data used in the creation of the plot. This functionality is same as in time series plotting and is explained in Section 8.1.3.6. However, in the case of scatter plots (unlike in time series plotting), the whole data set is shown always irrespective of whether the plot uses only a section of the data through 'Format Plot Axis' (Section 0) or the whole data set.

8.1.4.7 VIEW DATA FILE

View data file allows the user to look at the data files and the data contained in these

files in the project directory or in any other directory. This functionality is same as in time series plotting and is explained in Section 8.1.3.7.

8.1.4.8 DIGITISE DATA ON PLOT

Digitise data on plot allows the user to view data related to a point of the plot pointed by the mouse. By either selecting the *Tools::Digitise points* menu item or clicking on the  'Digitise data on plot' button on the toolbar in the REALM Plotting window (Figure 8-2), the user is presented with the information message as shown in Figure 8-22. Accept it by clicking on the **OK** button. Clicking on the plot and holding the left mouse button produces a little box containing the information about that particular point as shown in Figure 8-23. Releasing the left mouse button returns the user to the scatter plot.

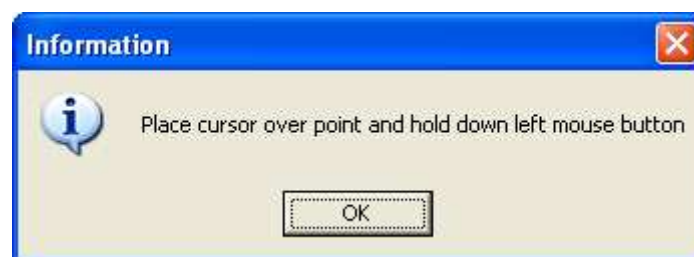


Figure 8-22 Information Dialog Box for Digitising Data on Scatter Plots

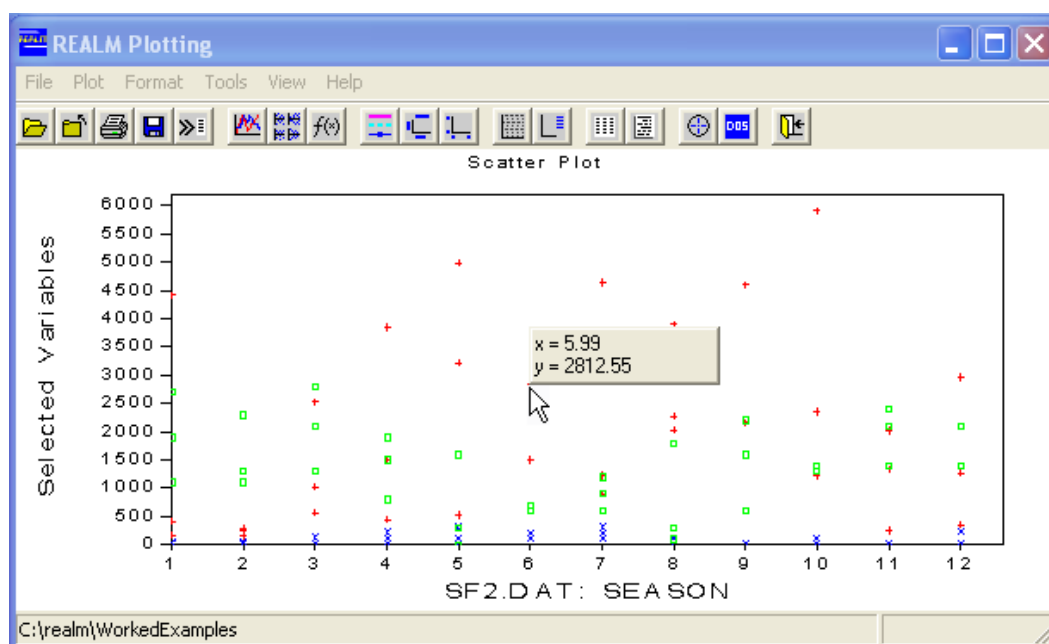



Figure 8-23 Digitise Data on Plot Dialog Box

8.1.5 TRANSFORMATION OF VARIABLES

Once the required files are loaded, the time series plotting, scatter plotting and data transformation menu items, and their respective buttons become active. The user is then able to transform variables of REALM format files by selecting the *Plot::Transform variables* menu item or clicking on the  'Transform/create new variables - $f(x)$ ' button on the toolbar of the REALM Plotting window Figure 8-2.

This displays the "Create temporary variables" dialog box (Figure 8-24), which

allows the user to create new variables from the existing variables of the selected data files. The dialog box shows the data file(s) selected by the user. The dialog box also shows the nine different operations which can be performed by the user when creating the new variables. The "Variables" partition at the bottom contains 'Variable X' and 'Variable Y', where the selected variable(s) for a particular operation are stored until they are transferred to the 'Temporary variables' list. The 'Temporary variable' list, contains the new (or temporary) variable(s). The operations required to create new (or temporary) variables are described in more detail below.

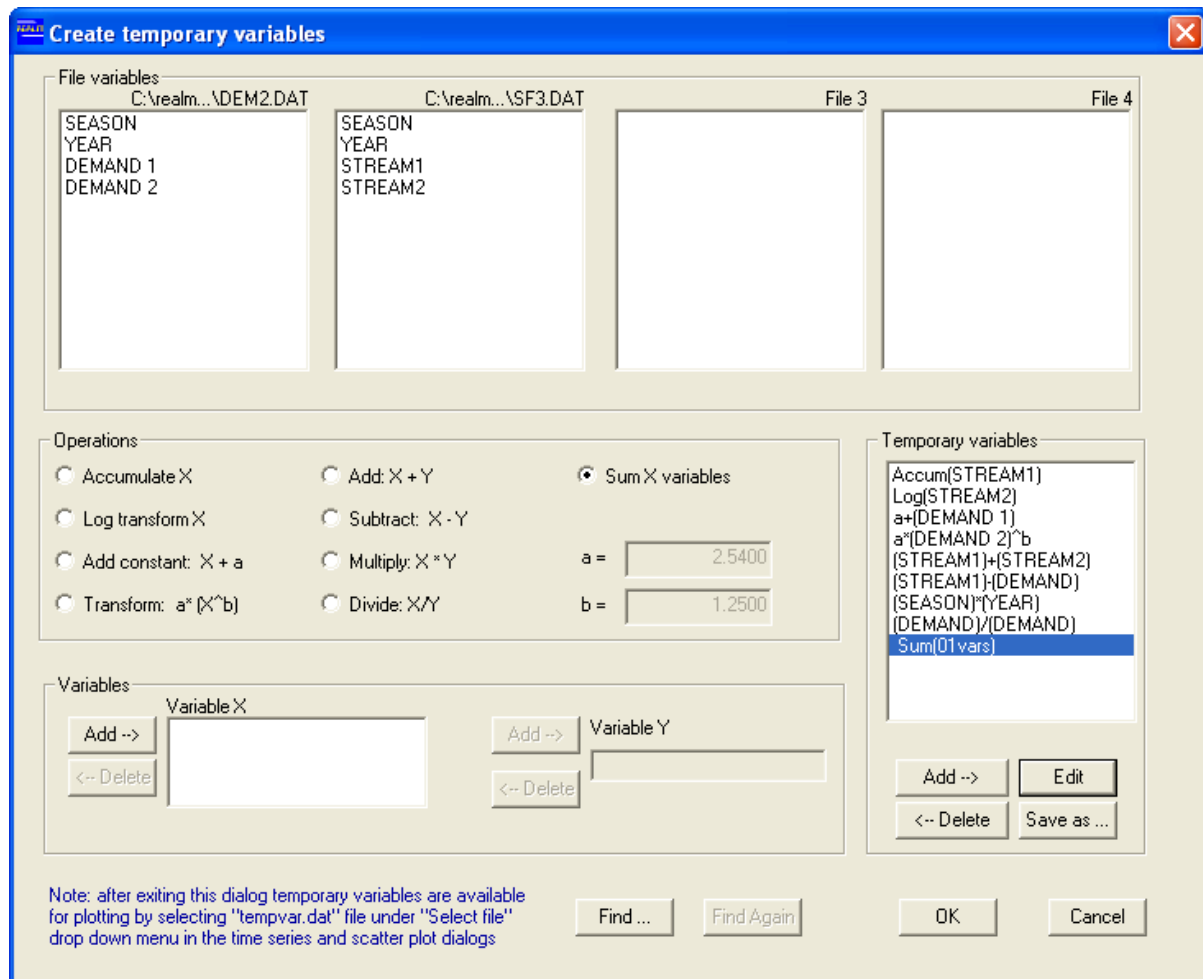


Figure 8-24 Create Temporary Variables Dialog Box

8.1.5.1 ACCUMULATE X

'Accumulate X' accumulates the values of the selected variable over the whole period of the time series, producing cumulative data with respect to each time step. The cumulative data series is useful in producing mass curves. The user must click on the 'Accumulate X' check box before selecting the required variable from the "File variables" partition. Clicking on the **Add** button of the 'Variable X' partition registers the selected variable in 'Variable X' partition. Then, the user must click on the **Add** button of the 'Temporary Variables' partition to create the new (or temporary) variable. This new variable appears as $Accum(X)$, where X is the selected variable.

8.1.5.2 LOG TRANSFORM X

'Log transform X' creates a new variable by transforming the data of the selected variable into the log domain over the whole period of the time series. The user must

click on the 'Log transform X' check box before selecting the required variable from the "File variables" partition. Clicking on the **Add** button of the 'Variable X' partition registers the selected variable in 'Variable X' partition. Then, the user must click on the **Add** button of the 'Temporary Variables' partition to create the new (or temporary) variable. This new variable appears as $\text{Log}(X)$, where X is the selected variable.

8.1.5.3 ADD CONSTANT: X + A

'Add constant: X + a' creates a new variable by adding a constant to the values of the selected variable over the whole period of the time series. The user must click on the 'Add constant: X + a' check box before selecting the required variable from the "File variables" partition. Clicking on the **Add** button of the 'Variable X' partition registers the selected variable in 'Variable X' list. The user must then specify the numeric value of the constant in the field 'a='. Then, the user must click on the **Add** button of the 'Temporary Variables' partition to create the new (or temporary) variable. This new variable appears as $a+(X)$, where X is the selected variable.

8.1.5.4 TRANSFORM $A*(X^B)$

'Transform $a*(X^b)$ ' creates a new variable through this function where 'a' and 'b' are constants. The user must click on the 'Transform $a*(X^b)$ ' check box before selecting the required variable from the "File variables" partition. Clicking on the **Add** button of the 'Variable X' partition registers the selected variable in 'Variable X' partition. The user must then specify the numeric values for both constants in the fields 'a=' and 'b='. Then, the user must click on the **Add** button of the 'Temporary Variables' partition to create the new (or temporary) variable. This new variable appears as $a*(X)^b$, where X is the selected variable.

8.1.5.5 ADD: X+Y

'Add: X+Y' allows the user to create a new variable by adding two selected variables over the whole period of the time series. The user must click on the 'Add: X+Y' check box before selecting the required variables from the "File variables" partition. Clicking on the **Add** button of the 'Variable X' partition registers the selected variable in 'Variable X' partition. Then the user must select the second required variable and click on the **Add** button of the 'Variable Y' partition. Then, the user must click on the **Add** button of the 'Temporary variables' partition to create the new (or temporary) variable. This new variable appears as $(X)+(Y)$, where X and Y are the selected variables.

8.1.5.6 SUBTRACT: X-Y

'Subtract: X-Y' allows the user to create a new variable by subtracting two selected variables over the whole period of the time series. The user must click on the 'Subtract: X-Y' check box before selecting the required variables from the "File variables" partition. Clicking on the **Add** button of the 'Variable X' partition registers the selected variable in 'Variable X' partition. Then the user must select the second required variable and click on the **Add** button of the 'Variable Y' partition. Then, the user must click on the **Add** button of the 'Temporary variables' partition to create the new (or temporary) variable. This new variable appears as $(X)-(Y)$, where X and Y are the selected variables.

8.1.5.7 MULTIPLY: X*Y

'Multiply: X*Y' allows the user to create a new variable by multiplying two selected variables over the whole period of the time series. The user must click on the 'Multiply: X*Y' check box before selecting the required variables from the "File

variables" partition. Clicking on the **Add** button of the 'Variable X' partition registers the selected variable in 'Variable X' partition. Then the user must select the second required variable and click on the **Add** button of the 'Variable Y' partition. Then, the user must click on the **Add** button of the 'Temporary variables' partition to create the new (or temporary) variable. This new variable appears as $(X)*(Y)$, where X and Y are the selected variables.

8.1.5.8 DIVIDE: X/Y

'Divide: X/Y' allows the user to create a new variable by dividing two selected variables. The user must click on the 'Divide: X/Y' check box before selecting the required variables from the "File variables" partition. Clicking on the **Add** button of the 'Variable X' partition registers the selected variable in 'Variable X' partition. Then the user must select the second required variable and click on the **Add** button of the 'Variable Y' partition. Click on the **Add** button of the 'Temporary variables' partition to create the new (or temporary) variable. This new variable appears as $(X)/(Y)$, where X and Y are the selected variables.

8.1.5.9 SUM X VARIABLES

'Sum X Variables' allows the user to create a new variable by adding several selected variables over the whole period of the time series. The user must click on the 'Sum X variables' check box before selecting the required variables from the "File variables" partition. For each variable, the user must select the variable first and click on the **Add** button of the 'Variable X' partition. This step must be continued until all required variables have been registered in the 'Variable X' partition. Once all the required variables have been added in the 'Variable X' partition, the user must click on the **Add** button of the 'Temporary variables' partition to create the new (or temporary) variable. This new variable appears as *Sum (xvars)*, where x represents the number of existing variables present in the 'Temporary variables' partition. This operation should be used for the addition of more than two variables, and can be used to create any number of temporary variables. However if the same number of variables are used in creating temporary variables, they will appear in the 'Temporary variables' partition with the same name. For example, two temporary variables each created by summing three (different) variables will both have the name "Sum(03vars)" in the 'Temporary variables' partition. However, these names can be changed using the **Edit** button in the 'Temporary variables' partition.

Notes:

- The user should be aware that it is possible to access the temporary variables created within the session in order to form another temporary variable. This is made possible by selecting the variable from the 'Temporary variable' partition, as opposed to selecting the variable from the list of variables from 'File variables'.
- Even if the temporary variables created in Figure 8-25 are not saved in a file (see 'Save as' button below), still the user can access these variables through the file *tempvar.dat* in time series and scatter plotting, provided the user has not exited from the REALM Plotting window (Figure 8-2).
- The user should also be aware that the temporary variables are no longer accessible upon exiting the REALM Plotting window.

Delete button

The **Delete** button (Figure 8-24) in the 'Temporary variables' partition allows the user to delete new (or temporary) variables. By selecting new variables to be deleted and clicking on the **Delete** button removes these variables from the 'Temporary variables' partition.

Edit button

The **Edit** button (Figure 8-24) in the 'Temporary variables' partition allows the user to change the name of the new (or temporary) variables. By selecting new variables to be edited and clicking on the **Edit** button, the user can edit the name of variable selected. Upon clicking on the **Edit** button, the user is presented with the "Edit Temporary Variable Name" dialog box (Figure 8-25). With this dialog box, the user can change the name of the temporary variable.

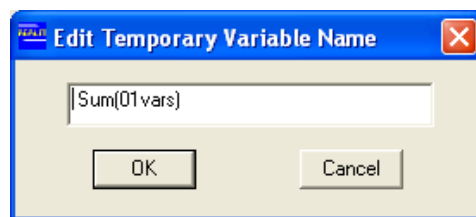


Figure 8-25 Edit Temporary Variable Name Dialog Box

Save as button

The **Save as** button (Figure 8-24) in the 'Temporary variables' partition allows the user to save the new (or temporary) variable(s) in a file, and allows the user to access this file later in a REALM session. By selecting the new variables to be saved and clicking on the **Save as** button, the user is presented with the standard "Save data to file" dialog box. Enter the filename and click on the **Save** button, to save the temporary variable(s) in this file.


Find and Find Again buttons

The **Find** button (Figure 8-24) allows the user to type in a text string when searching for a required variable. Clicking on the **Find** button opens the "Text Search" dialog box. Type the required text string (at least the first few letters/characters of the variable) and click on **OK** to highlight the variable with the same text string. Note that the search string is not case sensitive. If the text string selected by the user is applicable to more than one variable, clicking on the **Find Again** button selects the subsequent variables with the same search string.

OK and Cancel buttons


By clicking on the **OK** button (Figure 8-24), the user confirms the creation of the temporary variable(s), whereas clicking on **Cancel** in Figure 8-24 returns the user to the Plotting window.

8.1.6 SAVING PLOT


The current time series plot and scatter plot can be saved in a file and later imported to another Microsoft Windows application, such as Word. This can be done by selecting the *File::Save* menu item or clicking on the  *Save a REALM System file'* button on the toolbar to open the "Save plot to file" dialog box in the project directory. Note that the default file extension is *.wmf* (Windows metafile). Other file

types are available in the drop down list 'Save as type:'. The plot can be saved in any other directory through standard Windows browsing. Enter the appropriate filename and type, and save the plot by clicking on the **Save** button. After saving, the REALM Plotting window will be displayed again. Clicking on **Cancel** returns the user to the Plotting window without saving.


8.1.7 PRINT PLOT

The current time series plot or scatter plot can be printed from the REALM Plotting window. Another option is to save the plot as a file (Section 8.1.6) import it to another Microsoft Windows application, such as Word, and print it from there. Printing plots can be done by selecting the *File::Print* menu item or clicking on the  'Send plot file to printer' button on the toolbar. This displays the standard "Page Setup" dialog box found in Windows applications. Click on the **OK** button to print the plot or click on **Cancel** to return to the REALM Plotting window.

8.1.8 EXPORT PLOT

The data contained within the current time series plot or scatter plot can be saved using the Export function. This allows the user to save the data as a .DAT file. This file can be opened and edited (if necessary) through a standard editor such as Notepad in Windows or the Text Editor (Section 4.3.2) in REALM. This is done by selecting the *File::Export* menu item or clicking on the  'Export plot data to file' button on the toolbar. A standard Windows directory/file browser is displayed with *rpn.dat* as the default prompted filename. The plot data can be saved in any directory through standard Windows browsing. Enter the appropriate filename and save the file by clicking on the **Save** button. After saving, the REALM Plotting window is displayed again. Clicking on **Cancel** returns the user to the REALM Plotting window without saving data.

8.1.9 EXITING PLOT

In order to exit the utility Plot, either select the *File::Return* menu item or click on the  'Exit Plotting' button on the toolbar of the REALM Plotting window (Figure 8-2). This will take the user back to the REALM Program Manager (Figure 4-1).

8.2 FILTER

The Filter utility is used to extract columns of data from the given REALM output file (or any REALM 'formatted' file) and create a new file. Two filter options are available:

1. Monthly filter
2. Numeric filter

When *Utilities::Filter* is selected, the dialog box of Figure 8-26 is displayed.

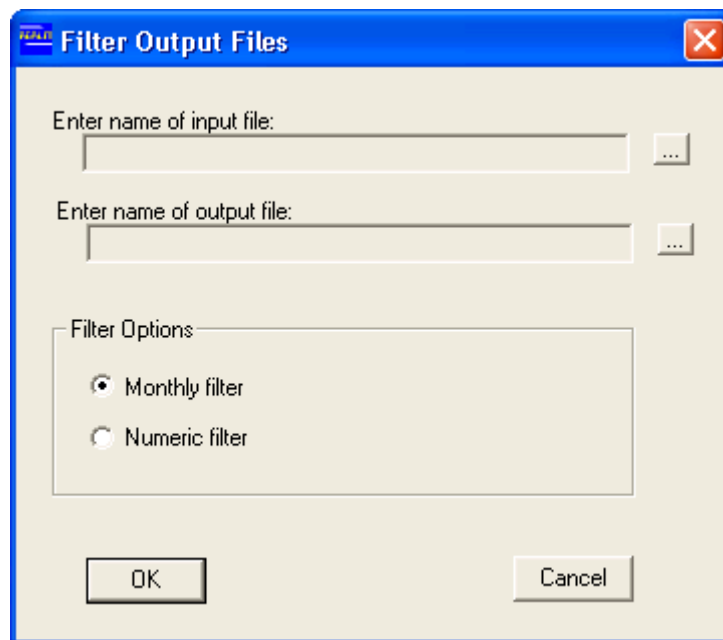


Figure 8-26 Filter Output Screen

Enter name of input file:

The name of the input file is entered here. The file should be in REALM format. The file can be selected by clicking on the **...** browse button.

Enter name of output file:

The output filename can be entered by clicking on the **...** browse button and then typing the filename.

Filter Options

The user is able to select data by Monthly filter or Numeric filter. These options are discussed in Section 8.2.1 and Section 8.2.2 respectively.

8.2.1 MONTHLY FILTER

If the Monthly filter option is selected, click on **OK** to display the dialog box shown in Figure 8-27.

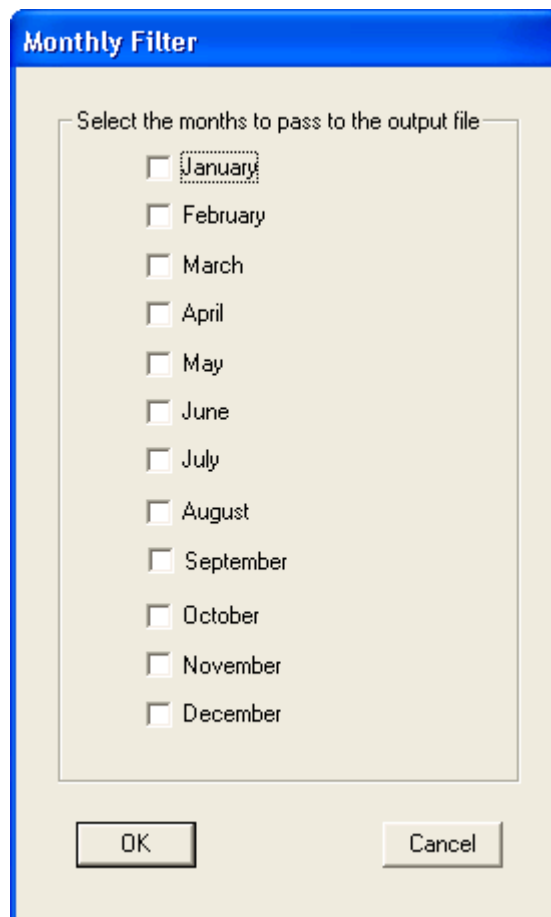


Figure 8-27 Monthly Filter Dialog Box

Click on the check boxes next to the month(s) for which data are to be displayed. Click on **OK**. The message box shown in Figure 8-28 is displayed.

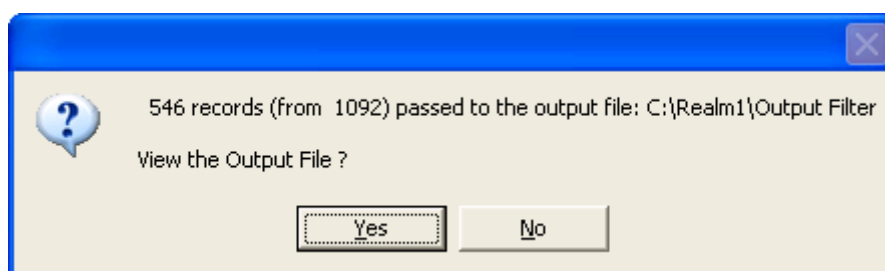


Figure 8-28 Filter Output File View Confirmation Message Box

Click **Yes** to view the the (filtered) file contents using the REALM Text Editor. Click **No** to return to the REALM Program Manager window (Figure 4-1) without applying a filter.

8.2.2 NUMERIC FILTER

If the Numeric filter option is selected from the "Filter Output Files" dialog box (Figure 8-26), the "Numeric Filter" dialog box (Figure 8-29) will be displayed, allowing the user to select a range of data to be filtered. The following filtering can be performed:

- Filtering data greater than a specified value
- Filtering data less than a specified value
- Filtering data equal to a specified value
- Filtering data not equal to a specified value.

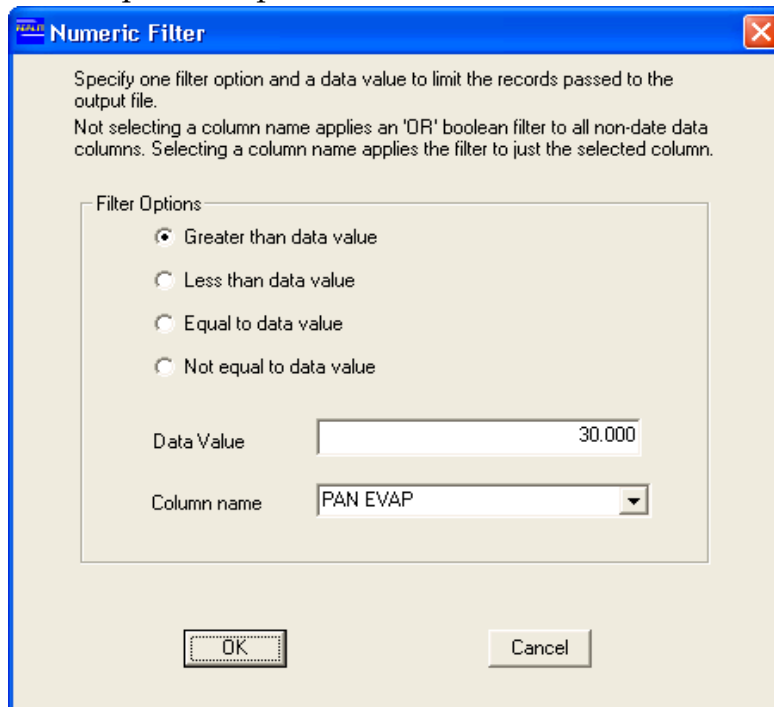


Figure 8-29 Numeric Filter Dialog Box

Only one selection can be made from the four filtering options listed in the dialog box. Select the appropriate “Filter options” radio button, and enter the data value corresponding to the selection in the ‘Data Value’ field (Figure 8-29).

Use the drop down box next to ‘Column name’ to specify which column the data are to be filtered by. When no column is selected in ‘Column name’, the records which satisfy the numeric condition in any data column will be passed to the output file. Restricting the ‘Column name’ to a specific column of data will pass to the output file those records in the selected column that satisfy the numeric condition. This utility is useful for removing zeros from a file, and highlighting storage volumes/carrier flows/restriction levels/streamflows greater than set values.

Figure 8-30 shows an output file generated by Numeric Filter restricting PAN EVAP column for values greater than 30, as the configuration shown in Figure 8-29.

```

FILTER
STREAMFLOW DATA FILE
HISTORICAL MONTHLY STREAMFLOW DATAFILE
NUMERIC FILTER      Time 07:39      Date 15/09/2005
NUMERIC FILTER .GT.      30.0 on PAN EVAP
( 5f12.2          )
  5
SEASON
YEAR
STREAM1          FILT
PAN EVAP        FILT
LOCAL RAIN      FILT
  1.00          1982.00      416.00      32.10      33.80
  2.00          1982.00      288.00      32.40      32.40
 12.00          1982.00      1269.00     30.20      31.40
  1.00          1983.00      172.00      30.80      31.30
  2.00          1983.00      160.00      34.40      35.20

```

Figure 8-30 Sample Output File of a Numeric Filter using Data Value Greater than 30 for the Column PAN EVAP

8.3 RANK

The Rank utility allows the user to select any column of data and rank the values of this column from highest to lowest, and also allows other data columns to be sorted/re-sequenced according to the ranked column. This utility can also be used to rank each of the columns of the input data file.

When the *Utility::Rank* menu item is selected, the “Rank Data” dialog box (Figure 8-31) is displayed.

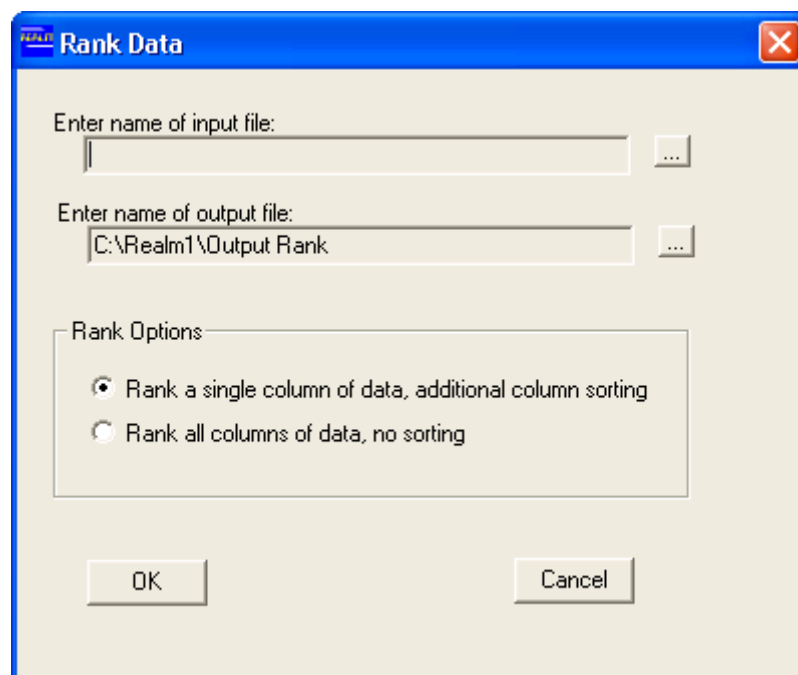



Figure 8-31 Rank Data Dialog Box

The name of the input file can be entered by clicking on the  browse button. In a similar manner, the output file can be specified. Two options exist in ranking data shown at the bottom of the dialog box as shown in Figure 8-31, and they are:

1. Rank a single column of data, additional column sorting

2. Rank all columns of data, no sorting.

8.3.1 RANK A SINGLE COLUMN OF DATA, ADDITIONAL COLUMN SORTING

Using this option the user is able to select the data column to be ranked, and specify the other data columns to be sorted.

Select the *'Rank a single column of data, additional column sorting'* radio button in the "Rank Data" dialog box (Figure 8-31).

Click the **OK** button.

The "Rank and Sort Data" dialog box (Figure 8-32) is displayed.

Use the corresponding drop down box to place an 'r' in the 'Action' field next to the name of the column to be ranked (Figure 8-32). Similarly, the columns to be sorted and re-sequenced corresponding to the ranked column can be assigned numeric values through their column names. Leaving the combo box blank for a particular column name leaves this column out of sorting.

After entering ranking and sorting information to column names, click on the **OK** button. A message box as shown in Figure 8-33 will appear. By clicking on **Yes**, the output file will be opened with REALM Text Editor. Clicking on **No** takes the user back to the REALM Program Manager (Figure 4-1).

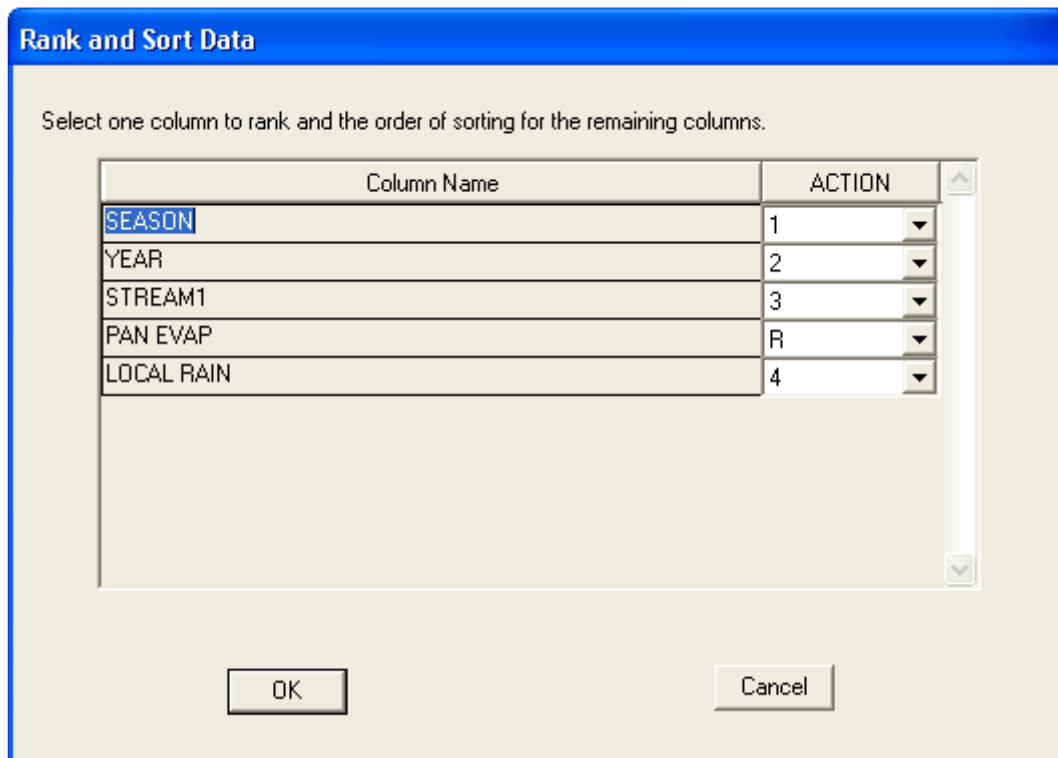


Figure 8-32 Rank and Sort Data Dialog Box

Figure 8-35 shows a sample output of the 'Rank a single column of data, additional column sorting' option of the Rank utility. In that sample file, PAN EVAP column was ranked and the other four columns were sorted accordingly. Note that the ranked column is ranked from highest to lowest, and the sorted columns are displayed as a record (i.e. values corresponding to that time step) corresponding to ranked values. In addition, the exceedance probabilities are displayed corresponding to each ranked value.

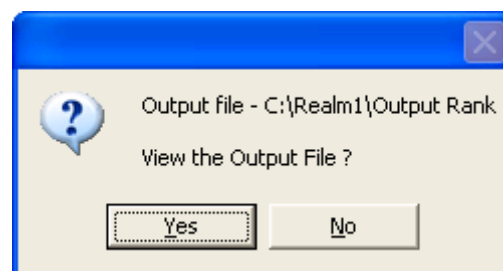


Figure 8-33 View Output File Confirmation Message Box

8.3.2 RANK ALL COLUMNS OF DATA, NO SORTING

This option can be selected from the "Rank Data" dialog box (Figure 8-31). After selecting this option and clicking on **OK** in that dialog box will prompt the user with a message box as shown in Figure 8-33. Click on **Yes** to open the output file with REALM Text Editor. Click on **No** to return to the REALM Program Manager (Figure 4-1) without viewing the output file.

```

RANK F
STREAMFLOW DATA FILE
HISTORICAL MONTHLY STREAMFLOW DATAFILE
TEST DATA
Time 07:51      Date 15/09/2005
( 6f12.2      )
6
PAN EVAP      RANK
SEASON        SORT
YEAR          SORT
STREAM1       SORT
LOCAL RAIN    SORT
EXCEEDANCE PROBAB. %
34.40      2.00      1983.00      160.00      35.20      2.70
32.40      2.00      1982.00      288.00      32.40      5.41
32.10      1.00      1982.00      416.00      33.80      8.11
30.80      1.00      1983.00      172.00      31.30      10.81
30.20      12.00     1982.00      1269.00     31.40      13.51
30.00      11.00     1982.00      1338.00     31.50      16.22
29.00      12.00     1983.00      2967.00     30.80      18.92
28.50      3.00      1983.00      566.00      128.90     21.62
28.50      2.00      1984.00      246.00      32.10      24.32
27.60      3.00      1982.00      1025.00     29.10      27.03
27.30      1.00      1984.00      4426.00     29.00      29.73
26.50      12.00     1984.00      353.00      230.10     32.43
25.80      11.00     1984.00      249.00      27.50      35.14
24.10      3.00      1984.00      2526.00     26.70      37.84
22.80      11.00     1983.00      2023.00     26.80      40.54
22.40      10.00     1982.00      1216.00     24.00      43.24
21.40      4.00      1982.00      450.00      123.90     45.95
21.30      4.00      1984.00      1513.00     22.70      48.65
20.50      10.00     1984.00      5910.00     23.90      51.35
20.10      10.00     1983.00      2360.00     123.20     54.05
. . .      . . .      . . .      . . .      . . .      . . .
. . .      . . .      . . .      . . .      . . .      . . .
    
```

Figure 8-34 Sample Output File of Rank Data

```

RANK F
STREAMFLOW DATA FILE
HISTORICAL MONTHLY STREAMFLOW DATAFILE
TEST DATA
Time 16:54      Date 14/09/2005
( 5f12.2      )
5
SEASON        RANK
YEAR          RANK
STREAM1       RANK
PAN EVAP      RANK
LOCAL RAIN    RANK
12.00      1984.00      5910.00      34.40      319.40
12.00      1984.00      4988.00      32.40      315.50
12.00      1984.00      4640.00      32.10      230.10
11.00      1984.00      4600.00      30.80      221.10
11.00      1984.00      4600.00      30.20      216.00
11.00      1984.00      4426.00      30.00      214.60
10.00      1984.00      3900.00      29.00      214.40
10.00      1984.00      3848.00      28.50      128.90
10.00      1984.00      3220.00      28.50      123.90
9.00      1984.00      2967.00      27.60      123.20
9.00      1984.00      2833.00      27.30      121.40
9.00      1984.00      2526.00      26.50      119.60
8.00      1983.00      2360.00      25.80      117.30
8.00      1983.00      2273.00      24.10      116.90
8.00      1983.00      2249.00      22.80      114.80
7.00      1983.00      2023.00      21.30      32.40
. . .      . . .      . . .      . . .      . . .
. . .      . . .      . . .      . . .      . . .
    
```

Figure 8-35 Sample Output File of Rank Data (Option 2)

In the output file, all data columns including SEASON and YEAR will be ranked as shown in Figure 8-35.

8.4 FORMAT CONVERSION

The Format Conversion utility performs two functions, as follows:

1. It can convert one column in a REALM format file into a 'matrix' of values. It can handle daily, weekly and monthly data.

For daily data: the matrix is produced as either one month per row, up to 31 columns of daily values, or one year per row with 365 columns of daily values.

For weekly data: the matrix is produced as one year per row with 52 columns of weekly values.

For monthly data: the matrix is produced as one year per row with 12 columns of monthly values.

2. It can compress the field width of columns in a REALM format file.

To open Format Conversion:

Click on the *Utilities::Format Conversion* menu item to display the, the "Format Conversion" dialog box (Figure 8-36).

Enter the names of input and output filenames using the standard Windows browsing facility.

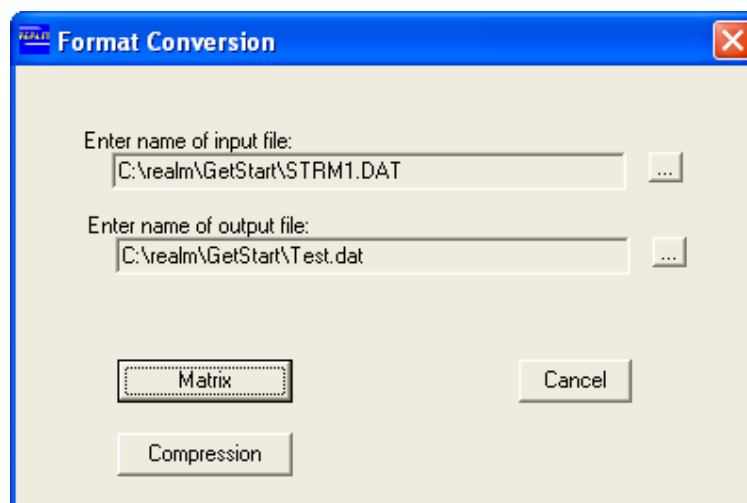


Figure 8-36 Format Conversion Dialog Box

8.4.1 MATRIX OPERATIONS

Click on the **Matrix** button to display the matrix input dialog box (Figure 8-37). Note that the "Data Type" in Figure 8-37 is "Monthly"; in this case, the utility has recognised the input data file as a monthly data file. If the input data file were weekly then "Data Type" would be shown as "Weekly". In the case of daily data files, the "Data Type" is shown as "Daily", and the "Format Options For Daily Data" block is active, so that the user can select either the 'One month per record' or the 'One

year per record' option, to convert the data into a matrix.

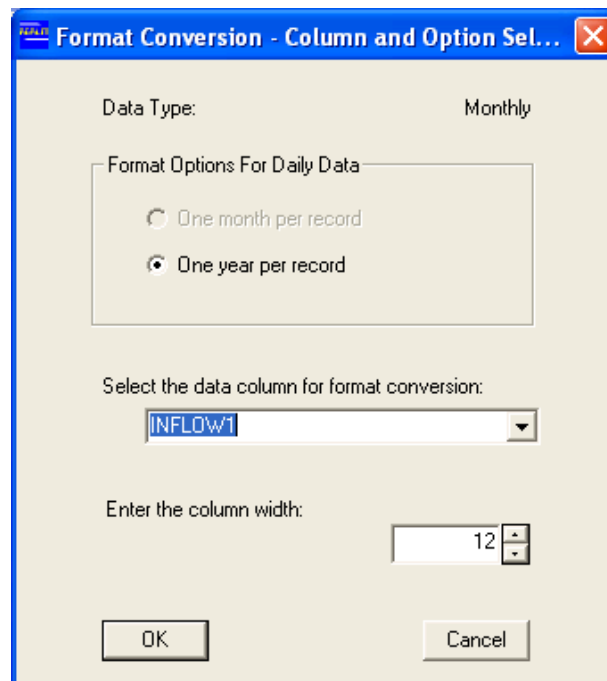


Figure 8-37 Matrix Input Dialog Box

The operations are similar for all time steps (except that daily data can be presented in two forms of matrix). Therefore, only the operations related to monthly data are described below.

Use the drop down box to populate the 'Select the data column for format conversion' field with the name of the data column to be presented as a matrix. In Figure 8-37, INFLOW1 has been selected. Note that the keywords (i.e. SEASON, YEAR and/or REPLICATE) are not shown in the combo box. The 'Enter the column width:' field sets the number of digits occupied by each data column. The default value is 12.

Click on the **OK** button. A message box as shown in Figure 8-38 will appear. Click on **Yes** to open the output file in the REALM Text Editor. Figure 8-39 is an example output file, showing a matrix of monthly data for the column name of INFLOW1. Click on **No** to return to the REALM Program Manager (Figure 4-1) without viewing the output file.

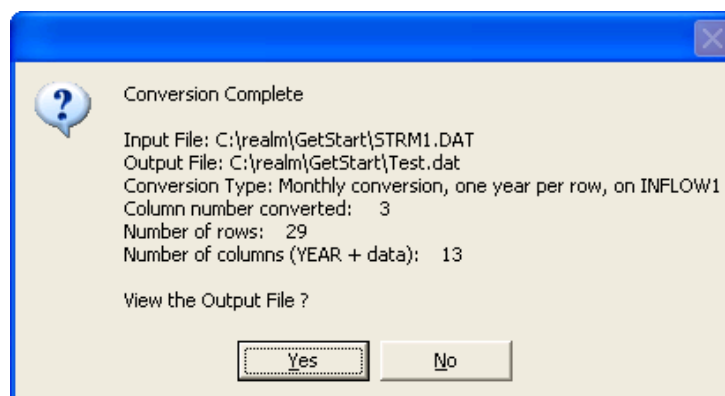


Figure 8-38 Conversion Summary Dialog Box

```

Format
REALM
GETTING STARTED - TUTORIAL EXAMPLE
Monthly conversion, one year per row, on INFLOW1
Time 21:05   Date 19/12/2005
(13f12.2    )
 13
YEAR
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1996.00  1250.00  1150.00   800.00   1400.00   2480.00   9600.00   8910.00  11200.00  10650.00  7400.00  4230.00  10578.00
1997.00  1400.00  1550.00  1230.00   2100.00   3460.00   7760.00  12350.00  15790.00  12340.00  7200.00  3060.00  2100.00
1998.00   800.00   950.00   780.00   1100.00   2940.00   9900.00  11110.00  19500.00  15100.00  8900.00  3960.00  1830.00
1999.00   750.00   880.00   700.00   1870.00   5130.00   8960.00  14500.00  11800.00  17080.00  10350.00  7800.00  1620.00
2000.00   950.00   880.00   460.00   1880.00   4860.00   8020.00  14780.00  15800.00  14890.00  11050.00  7850.00  2330.00
2001.00  1080.00   780.00   890.00   1400.00   4020.00  12500.00  10090.00  15400.00  11800.00  9500.00  5260.00  3300.00
2002.00  1470.00  1560.00  1320.00   3400.00   5760.00   8970.00  12670.00  17730.00  12060.00  9870.00  5300.00  1640.00
2003.00  2100.00  1800.00  1560.00  3200.00   6500.00   8760.00  14600.00  20010.00  17000.00  11250.00  6050.00  3200.00
2004.00  1960.00  2010.00  1860.00  2780.00   3050.00   6360.00  12850.00  18430.00  12400.00  10450.00  4780.00  2010.00
2005.00  1430.00  1250.00  1120.00  1970.00   2250.00   4890.00   9990.00  12500.00   9910.00  7850.00  3250.00  1870.00
2006.00  1020.00   870.00   450.00  1370.00  1890.00   3480.00   7700.00  10020.00  8700.00  7190.00  3050.00  1420.00
2007.00   720.00   450.00   320.00   990.00  1250.00   3000.00   6570.00   9430.00  7300.00  6900.00  3550.00  2070.00
2008.00   460.00   380.00   300.00  1030.00  2590.00   4520.00   9080.00   9990.00  7040.00  5860.00  4900.00  2200.00
2009.00  1100.00   920.00   750.00  1850.00  3700.00   6350.00  10050.00  11540.00  8700.00  4250.00  5100.00  2350.00
2010.00  1300.00  1200.00   980.00  2780.00  4080.00   7810.00  12340.00  12790.00  10780.00  5400.00  6070.00  3160.00
2011.00  1370.00  1230.00  1000.00  2430.00  3780.00   5670.00   9920.00  12430.00  10850.00  5020.00  4780.00  2760.00
2012.00   860.00  1100.00   920.00  2014.00  2630.00   4860.00  10760.00  12350.00  11850.00  6750.00  3350.00  1900.00
2013.00   500.00   760.00   890.00  1350.00  1920.00   4300.00   8900.00  11120.00  10000.00  7800.00  5450.00  3200.00
2014.00  1820.00  1230.00  1230.00  2250.00  3860.00   7160.00  12800.00  13260.00  9500.00  9860.00  6200.00  980.00
2015.00   780.00  1070.00   880.00  2200.00  4570.00   7660.00  13540.00  17450.00  12000.00  10890.00  7800.00  1200.00
2016.00  1400.00  1120.00   980.00  1560.00  4020.00   7050.00  14090.00  18900.00  13000.00  9800.00  4650.00  2030.00
2017.00  1090.00  1230.00  1780.00  1890.00  3250.00   6890.00  12090.00  13240.00  11350.00  8900.00  3560.00  1450.00
2018.00  1650.00  1620.00  2560.00  2500.00  4400.00   6700.00  10050.00  12450.00  8900.00  7680.00  3460.00  1980.00
2019.00  1780.00  1540.00  1340.00  3020.00  5670.00   8900.00  12340.00  15670.00  8740.00  5060.00  3140.00  1890.00
2020.00  1030.00  1110.00   870.00  1980.00  4350.00   7590.00  11560.00  13270.00  7680.00  6180.00  2070.00  1530.00
2021.00   880.00   760.00   640.00  1270.00  4700.00   7890.00   9700.00  12450.00  7420.00  7270.00  3260.00  2090.00
2022.00  1250.00  1150.00   800.00   1400.00   2480.00   9600.00   8910.00  11200.00  10650.00  7400.00  4230.00  10578.00
    
```

Figure 8-39 Output File of Matrix of Monthly Values

8.4.2 FILE COMPRESSION

Click on the 'Compression' button of the "Format Conversion" dialog box (Figure 8-36), to create an output file that has the same information as the input file, but data stored with reduced column widths. Figure 8-40 shows such an output file, created with the input file *STRM1.DAT* (which is in *C:\realm\GetStart* directory). The original format was (5F12.2), while the new format of the output file is (f4.0,f6.0,2f5.0,f4.0).

```

####2
REALM
GETTING STARTED - TUTORIAL EXAMPLE
STREAMFLOW DATA
JULY -1997
(f4.0,f6.0,2f7.0,2f5.0,f4.0)
  7
SEASON
YEAR
INFLOW1
INFLOW2
CLINX
RAIN
EVAP
  1. 1996. 1250. 312. 110. 30. 70.
  2. 1996. 1150. 219. 110. 50. 60.
  3. 1996. 800. 202. 105. 60. 50.
  4. 1996. 1400. 175. 100. 70. 40.
  5. 1996. 2480. 712. 100. 75. 35.
  6. 1996. 9600. 1018. 90. 90. 25.
  7. 1996. 8910. 1608. 90. 95. 10.
  8. 1996. 11200. 3701. 100. 90. 25.
  9. 1996. 10650. 1870. 105. 80. 35.
 10. 1996. 7400. 2350. 105. 70. 40.
 11. 1996. 4230. 1728. 110. 50. 50.
 12. 1996. 10578. 926. 115. 40. 60.
  1. 1997. 1400. 667. 110. 30. 70.
  2. 1997. 1550. 451. 110. 50. 60.
  3. 1997. 1230. 302. 105. 60. 50.
  4. 1997. 2100. 256. 100. 70. 40.
  5. 1997. 3460. 723. 100. 75. 35.
  6. 1997. 7760. 1567. 90. 90. 25.
  7. 1997. 12350. 5313. 90. 95. 10.
  8. 1997. 15790. 2646. 100. 90. 25.

```

Figure 8-40 Output File of File Compression Utility

8.5 CALCULATOR

The Calculator utility allows the user to create new data columns by performing mathematical operations on existing data columns. The input data file must be a REALM format file (daily, weekly, or monthly), which may or may not contain

replicates. This utility has six calculation options. All the options produce REALM format output files, which can be used as streamflow or demand files, or as input to other REALM utilities.

Click on the *Utility::Calculator* menu item to display the “Calculator Utility” dialog box (Figure 8-41). Use the browser buttons to enter the input and output filenames. The data of the input file can be used to generate new output via an equation. The equation produces lines of output by performing the same manipulation for each line of the input file.

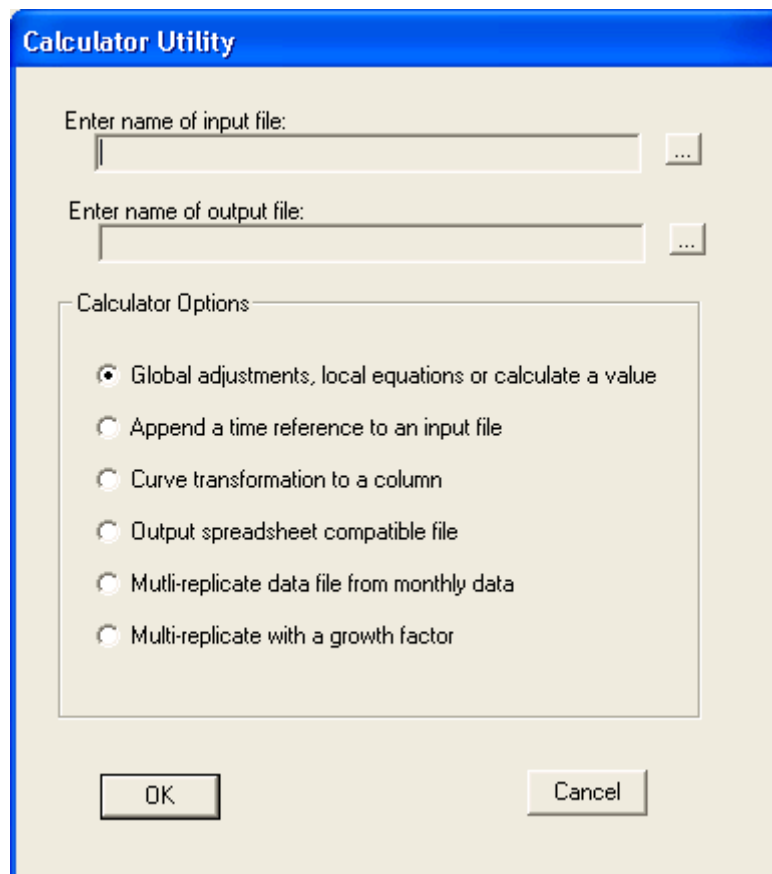


Figure 8-41 Calculator Utility Dialog Box

8.5.1 GLOBAL ADJUSTMENTS, LOCAL EQUATIONS OR CALCULATE A VALUE

8.5.1.1 GLOBAL ADJUSTMENTS/LOCAL EQUATIONS

Click on the ‘*Global adjustments, local equations or calculate a value*’ radio button (Figure 8-41). The “Global Adjustments and Local Equations” dialog box is displayed (Figure 8-42). It has two blocks:

1. “Global adjustments and local equation/adjustments”
2. “Calculate a value from a local equation/adjustment”.

Note that the global adjustments and local equation contain equations similar to those used in computing the capacity of variable carriers. Note also the text in the “Equation and Adjustment Information” block (Figure 8-42).

Global Adjustments and Local Equations

Global adjustments and local equation / adjustments

Global adjustment : Apply global adjustment to all columns Negative values to zero for both local and global equations and adjustments

Select columns to apply global adjustment OR input column specific adjustments :

Column Name	Global Adjust	No.	Local Equation / Adjustment	Output Type	New Column Name
SEASON	<input type="checkbox"/>	1			
YEAR	<input type="checkbox"/>	2			
STREAM1	<input type="checkbox"/>	3	2300/*3	New file-Output column on	N_STREAM1

Calculate a Value from a local equation / adjustment

Column :

Equation and Adjustment Information

Calculation Order : Local adjustments / equations are performed on the results of global
Input columns to equations contain only the results of prior global adjustments,
not the results of their own equations.

Equation Operators : + - / * ** ^ ()

Equation Functions : EXP LOG LOG10 ABS MIN MAX SQRT MOD COS
SIN TAN MTH IF P1 N1 RND

Adjustments Syntax : One of first 4 operators (+, -, /, or *) and up to 20 digits, which may
include the minus sign.

Figure 8-42 Global Adjustments and Local Equations Dialog Box

The global adjustments/local equations allow the user to change one column or many columns for the input data file. Global adjustments can be made for all columns (by clicking on the 'Apply global adjustment to all columns' check box) or selected columns (by clicking on the 'Global adjust' check box next to the name of each data column to be transformed).

The 'Output Type' field enables the user to specify how the new data created by global adjustments/local equations is to be written to the output file. There are four options provided in the drop down boxes:

- by replacing the specific column in the input file ("Replace column")
- by appending the new data columns to the input file ("Append as new column")
- by having only a single column with new data ("New file - Output column only")
- by having only the input and output columns ("New file- Input & output columns").

Whenever a global/local adjustment is made to a column, a new column name must be specified for that particular column where the global/local adjustments are made. Any global adjustment is performed first and then the local adjustments are done on the results of the global adjustment.

Note that the global adjustment is applied to all selected column in the same way, but the local adjustment is specific to the column where the local equation/adjustment is made.

Note also that negative values created by global and/or local adjustments can be set to zero by selecting the check box 'Negative values to zero for both local and global equations and adjustments'.

8.5.1.2 CALCULATE VALUES FROM LOCAL EQUATION/ADJUSTMENT

The "Calculate a Value from a local equation/adjustment" block allows the user to test the equation for the first data item in the specified row by instantly calculating and displaying the output on the screen.

To calculate a value:

Select the column to be examined from the drop down box "Column". Note that the selected column should have at least local equation/adjustment field of the 'global adjustments and local equation/adjustments' compartment. The user may select to do global adjustments or setting negative values to zero after global/local adjustments. Similar to global/local adjustments above, the global adjustment are done first and then the local adjustments are done on the results of the global adjustments.

Figure 8-43 shows the results for one such operation.

```

CALC F
STREAMFLOW DATA FILE
HISTORICAL MONTHLY STREAMFLOW DATAFILE
TEST DATA
Time 20:44      Date 15/09/2005
( 3f12.2      )
  3
YEAR
SEASON
N_STREAM1
1982.00      1.00      5.53
1982.00      2.00      7.99
1982.00      3.00      2.24
1982.00      4.00      5.11
1982.00      5.00      0.46
1982.00      6.00      1.02
1982.00      7.00      1.86
1982.00      8.00      1.01
1982.00      9.00      1.06
1982.00     10.00      1.89
1982.00     11.00      1.72
1982.00     12.00      1.81
1983.00      1.00     13.37
1983.00      2.00     14.38
1983.00      3.00      4.06
1983.00      4.00      0.60
1983.00      5.00      0.71
1983.00      6.00      1.53
1983.00      7.00      0.50
. . .
. . .
    
```

Figure 8-43 Results of a 'Global adjustments, local equations or calculate a value' Operation

8.5.2 APPEND A TIME REFERENCE TO AN INPUT FILE

This option is used to generate SEASON and YEAR columns in data files (the input files may or may not already have those columns).

To append a time reference to an input file:

Click on the 'Append a time reference to an input file' radio button (Figure 8-41). This displays the "Add Time Column" dialog box (Figure 8-44).

Type the name of the new time-reference columns in the 'New Season Column Name' field and the 'New Year Column Name' field. The key words "SEASON" and "YEAR" may be used. Alternatively, the new columns of data must be given any names.

Figure 8-44 Add Time Column

The 'Start Season', 'Start Year' and 'Number of Seasons' fields must be populated. For monthly data, set the 'Number of Seasons' to 12. Use 52 and 365 for weekly and daily data respectively.

Click on **OK**. The "Append a Time Reference" dialog box (Figure 8-45) is displayed. Click **Yes** to append the new time references as the first two columns in the output file. Click **No** to append the new time references as the last two columns in the output file.

Figure 8-45 Append a Time Reference Dialog Box

8.5.3 CURVE TRANSFORMATION TO A COLUMN

This option is used to generate a data column representing a linear or non-linear translation of one of the columns of the input file. Only one data item can be produced per run and it is always appended to the input file. This option can be used to convert storage volumes into storage water levels via a rating curve, or to

check the calculations of variable capacity carrier relationship by re-typing the relationship of the system file.

To perform curve transformation:

Click on the 'Curve transformation to a column to generate a new column' radio button in the "Calculator Utility" dialog box (Figure 8-41). The "Curve Calculations" dialog box is displayed (Figure 8-46).

Select the input data column (which becomes the independent variable in the transformation table) from the drop down box "Select reference column".

Enter the transformation table from the lowest value of the independent variable to the highest in the 'Indep. variable (x)' and 'Dep. variable (y)' fields.

Type the name of the output data column in the "Enter new column name" text box. (This column name becomes the dependent variable.) Linear interpolation is used to generate the new column between the values defined in the transformation table.

Click on the **OK** button to generate the new column of data. The output file resembles the input file, but with an additional column of (transformed) data appended to it.

The dialog box is titled "Curve Calculations". It contains the following elements:

- Select reference column :** A dropdown menu.
- Enter data points from lowest x to highest x :** A table with 10 rows and 3 columns:

Point	Indep. variable (x)	Dep. variable (y)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
- Enter new column name :** A dropdown menu.
- OK** and **Cancel** buttons at the bottom.

Figure 8-46 Curve Calculations Dialog Box

8.5.4 OUTPUT SPREADSHEET COMPATIBLE FILE

This option converts a REALM format file to spreadsheet format. Click on the 'Output spreadsheet compatible file' radio button to perform this task (Figure 8-41).

8.5.5 MULTI-REPLICATE DATA FILE FROM MONTHLY DATA

In performing operational studies, often different input sequences of data are required for a future operational period (i.e. 12 month period or more). These sequences represent the different possible inputs that may be experienced over this period, and are most often based on historic or generated data. The operational rules are developed from statistical inferences of all different outcomes due to above possible inputs.

These possible input sequences can be considered as replicates for the operational period. They can be generated from an existing data file, by 'recycling' data. Usually, the input file contains historic data. Both (historic) streamflow and (historic) demand files can be used as input. This option creates a multi-replicate output file which can be directly used by REALM.

Note that this option can be used only with input files with monthly data.

To produce multi-replicate data from monthly data:

Click on the 'Multi-replicate data file from monthly data' radio button (Figure 8-41). The "Create a Multi-Replicate File" dialog box (Figure 8-47) is displayed.

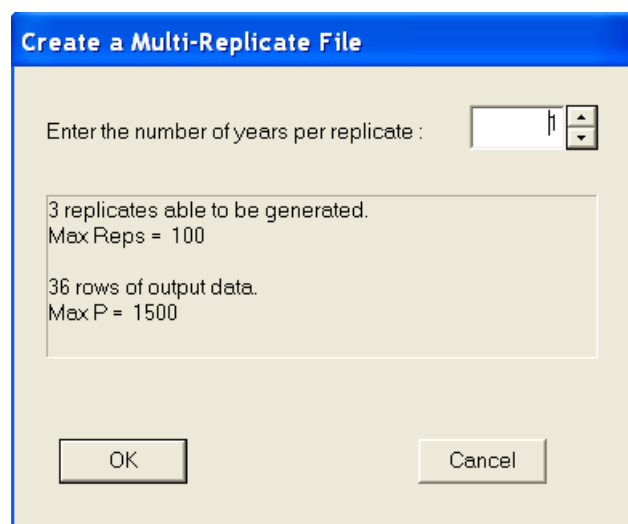


Figure 8-47 Create a Multi-Replicate File Dialog Box

Figure 8-47 has been produced for the care of an input file which has 3 years of monthly data. This input data file can be used to generate monthly replicate data having either 1 or 2 years per replicate. Note that 3 years per replicate will give only one replicate and it is then same as the input file. Figure 8-47 also gives the information about how many replicates and how many rows of data are generated with different number of years per replicate. It also gives the maximum permissible number of replicates and rows of data that can be generated under current default settings of "Max Reps" (maximum number of replicates) and "MaxP" (maximum number of data rows). Note that the settings can be changed, if required through the "Dynamic Memory" tab of *Run::Options*.

Enter the number of years per replicate and click on **OK** to produce the required multi-replicate output file.

Figure 8-48 shows the output file corresponding to input information of Figure 8-47.

Note that the number of years per replicate has been requested as 1 year in Figure 8-47.

```

CALC F
STREAMFLOW DATA FILE
HISTORICAL MONTHLY STREAMFLOW DATAFILE
TEST DATA
Time 06:32      Date 27/05/2005
( 6f12.2      )
  6
YEAR
SEASON
REPLICATE
STREAM1
PAN EVAP
LOCAL RAIN
1982.00      1.00      1.00      416.00      32.10      33.80
1982.00      1.00      2.00      172.00      30.80      31.30
1982.00      1.00      3.00      4426.00     27.30      29.00
1982.00      2.00      1.00      288.00      32.40      32.40
1982.00      2.00      2.00      160.00      34.40      35.20
1982.00      2.00      3.00      246.00      28.50      32.10
1982.00      3.00      1.00      1025.00     27.60      29.10
1982.00      3.00      2.00      566.00      28.50      128.90
1982.00      3.00      3.00      2526.00     24.10      26.70
1982.00      4.00      1.00      450.00      21.40      123.90
1982.00      4.00      2.00      3848.00     19.70      221.10
1982.00      4.00      3.00      1513.00     21.30      22.70
1982.00      5.00      1.00      4988.00     16.00      119.60
1982.00      5.00      2.00      3220.00     16.40      319.40
1982.00      5.00      3.00      525.00      16.80      20.10
1982.00      6.00      1.00      2249.00     12.30      214.60
1982.00      6.00      2.00      1500.00     11.30      216.00
1982.00      6.00      3.00      2833.00     14.60      117.30
1982.00      7.00      1.00      1234.00     11.90      315.50
1982.00      7.00      2.00      4640.00     11.70      114.80
1982.00      7.00      3.00      908.00      11.60      214.40
1982.00      8.00      1.00      2273.00     17.10      121.40
. . .      . . .      . . .      . . .      . . .      . . .
. . .      . . .      . . .      . . .      . . .      . . .
    
```

Figure 8-48 Example of a Multi-Replicate Output File from Calculator

8.5.6 MULTI-REPLICATE WITH A GROWTH FACTOR

In yield studies, the user typically performs successive runs with increasing demands. The demand level at which a set security criterion fails is deemed to be the yield of the system at that level of security. Effectively each replicate corresponds to a discrete level of demand.

Generating the demand files and performing the simulation for each demand level can be monotonous and error prone. This Calculator option allows the user to generate multi-replicate data files. REALM runs through all replicates in a single pass and, as such, the user need only do one simulation run to get access to results for all pre-set levels of demand. As an example of generating a multi-replicate demand file, the demands can be generated from an historic demand file and each replicate increased by 1%. The user generates enough replicates to cover the system failure and then performs the simulation. To complete the data requirements, the user has to generate a compatible multi-replicate streamflow file. This can be done

by simply duplicating the original data for each replicate or by adding a small random component.

Multi-Replicate Options

Enter multi-replicate adjustment equation :

Number of replicates :

Negative values to zero

Select columns for adjustment :

Apply to all columns

Column No.	Column Name	Global Adjustment	Local Adjustment
1	SEASON	<input type="checkbox"/>	
2	YEAR	<input type="checkbox"/>	
3	WATTS RIVER	<input type="checkbox"/>	
4	GRACEBURN	<input type="checkbox"/>	
5	CORANDERRK	<input type="checkbox"/>	
6	YERING INC	<input type="checkbox"/>	
7	OSHANNASSY	<input type="checkbox"/>	
8	YAN YEAN	<input type="checkbox"/>	
9	UPPER YARRA	<input type="checkbox"/>	
10	YARRA TRIBS	<input type="checkbox"/>	
11	THOMSON 94	<input type="checkbox"/>	

Adjustment Information

Operators : + - / * % R

Adjustments Syntax: One of first 4 operators (+, -, /, or *) and up to 20 digits, which may include the minus sign.

OK Cancel

Figure 8-49 Multi-Replicate with Growth Dialog Box

To produce multi-replicate data with a growth factor:

Click on the 'Multi-replicate with a growth factor' radio button, which displays the "Multi-Replicates With Growth" dialog box (Figure 8-49). Enter the equation in the 'Enter multi-replicate adjustment equation' field and the required number of replicates in the 'Number of replicates' field. Note that the option exists to apply the adjustment to all the columns (except SEASON and YEAR) or to select the columns for adjustment individually. Also the user can enter a local adjustment to the columns of data, which have been already generated by the global adjustment. Note also the user can set the negative values generated by global/local adjustments to zero, by clicking on the check box 'Negative values to zero'. The adjustment information (i.e. operators and adjustment syntax) is given in Figure 8-49.

8.6 MERGER

The Merger utility allows REALM format data files to be merged to create a new REALM format file.

To merge files:

Click on the *Utility::Merger* menu item.

The “Merger File Utility” dialog box (Figure 8-50) is displayed. Up to four input files can be entered using the standard browsing facility. The output filename also should be entered.

Click on **OK** to display the “Merger File Column Selection” dialog box (). This dialog box allows the user to select data columns from the input files and merge them to create the new output file. Click on the ‘Select input files to select columns for merge’ combo box to select the required input file and columns to be merged.

Numeric entries should be used in to select the column names. Different numeric entries will produce the data columns as separate items in the output file. Use the same digit to add two or more columns of data. Similarly, use the same digit with the negative sign preceding to subtract the columns of data. Some selections are shown in . In it is intended to create an output file (or a merged file) with SEASON, YEAR and STREAM1 as separate columns and another column as the difference between PAN EVAP and LOCAL RAIN. Note that all these data columns are from C:\REALM\utilitytesting\SF2.DAT only, although additional columns from other files can be considered in a similar way with appropriate numeric digits.

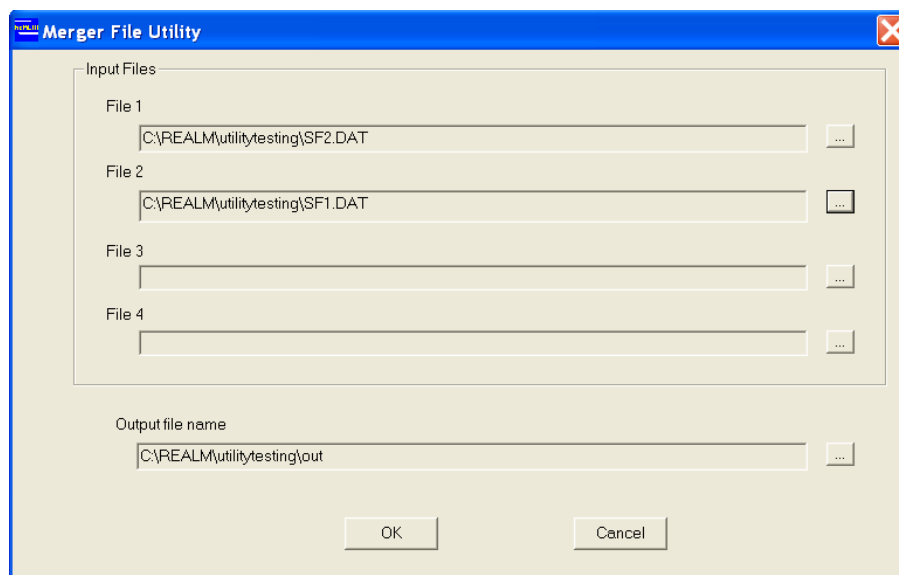


Figure 8-50 Merger File Utility Dialog Box

The output file corresponding to the selection shown in is given in Figure 8-52.

If the selected files cover different time periods, then a warning message will appear, as shown in Figure 8-53, giving the user the option to either proceed with the merger of the concurrent data only or to cancel the merger.

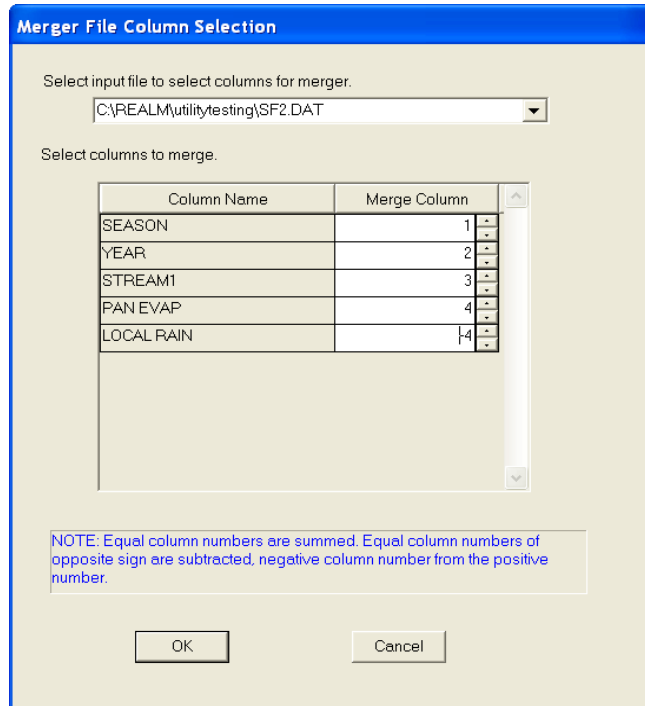


Figure 8-51 Merger File Column Selection Dialog Box

```

####4
STREAMFLOW DATA FILE
HISTORICAL MONTHLY STREAMFLOW DATAFILE
TEST DATA
DATE : 20 JUL 1990
( 4f12.2 )
 4
SEASON
YEAR
STREAM1
Columns added here
 1.00 1982.00 416.00 -1.70
 2.00 1982.00 288.00 0.00
 3.00 1982.00 1025.00 -1.50
 4.00 1982.00 450.00 -102.50
 5.00 1982.00 4988.00 -103.60
 6.00 1982.00 2249.00 -202.30
 7.00 1982.00 1234.00 -303.60
 8.00 1982.00 2273.00 -104.30
 9.00 1982.00 2160.00 -3.60
10.00 1982.00 1216.00 -1.60
11.00 1982.00 1338.00 -1.50
12.00 1982.00 1269.00 -1.20
 1.00 1983.00 172.00 -0.50
 2.00 1983.00 160.00 -0.80
 3.00 1983.00 566.00 -100.40
 . . . . .
 . . . . .
 . . . . .
10.00 1983.00 2360.00 -103.10
11.00 1983.00 2023.00 -4.00
12.00 1983.00 2967.00 -1.80
 1.00 1984.00 4426.00 -1.70
 2.00 1984.00 246.00 -3.60
 3.00 1984.00 2526.00 -2.60
 . . . . .
 . . . . .
10.00 1984.00 5910.00 -3.40
11.00 1984.00 249.00 -1.70
12.00 1984.00 353.00 -203.60
    
```

Figure 8-52 Merger Output File Corresponding to Selection

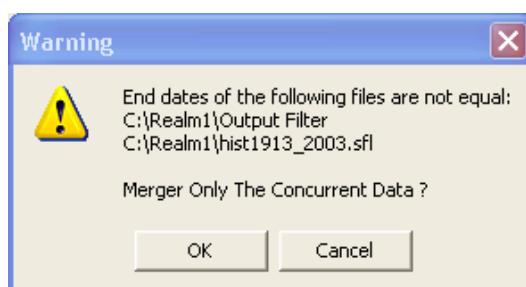


Figure 8-53 Message Box Displayed for SEASON Incompatibility in Input Files

8.7 REPLICATE ANALYSIS

The Replicate Analysis utility is used in multi-replicate mode to get an idea of risk associated with the decision variables. Multi-replicate simulation can be done in two ways in REALM as follows:

Multi-replicate run with an annual demand file and the historical (seasonal) streamflow file - In this case, the streamflow replicates are generated within REALM,

by concatenating the streamflow sequence by itself, and starting each sequence with data corresponding to a different year, but continuing for N number of years, where N is the number of years in historic streamflow data sequence. This method can generate a maximum of N streamflow replicates, which are different to each other. These data are commonly known as 'recycled data'. The recycled data concept and methodology in generating these data are described in McMahon and Mein (1986). The annual demand is considered to be the same for each replicate in the REALM simulation. This approach (i.e. recycled data generation and subsequent simulation) is built-in to REALM, and can be set during REALM Setup (Section 6.3.1).

Multi-replicate run with seasonal streamflow and demand files that contain replicate data - During simulation, REALM does the simulation for a simulation time step for all replicates, and then moves to the next time step, and so on, until it reaches the end of the simulation.

In both cases, the output files (except the log file) are REALM format files and have data corresponding to replicates. A part of a multi-replicate streamflow file is shown Figure 8-54, which has 10 replicates. The REALM format output files are similar. The log file contains average values with respect to the simulation time step and the number of replicates.

In some cases, it is necessary to extract data corresponding to certain replicates from these multi-replicate input and output files. In other cases, it may be necessary to analyse these multi-replicate data to get the statistical parameters of certain decision variables. Both extraction and analysis of multi-replicate data can be done using the Replicate Analysis utility.

To analyse multi-replicate data:

Select the *Utilities::Replicate Analysis* menu item. The "Replicate Utilities" dialog box (Figure 8-55) is displayed.

Enter the multi-replicate input filename and the output filenames for the Replicate Analysis. The input file can be a user-prepared file (such as streamflow file of Figure 8-54) or an output file from a REALM multi-replicate run. Note that the field '*Enter the output filename for annual data (Analysis Only)*' is required only for analysing replicates to obtain the annual statistical parameters of various decision variables (or column variables of the input files).


```

####2
REALM
GETTING STARTED - TUTORIAL EXAMPLE
STREAMFLOW DATA
Time 06:05   Date 31/10/2005
( 8f12.2    )
  8
YEAR
SEASON
REPLICATE
INFLOW1
INFLOW2
CLINX
RAIN
EVAP
1996.00      1.00      1.00      1250.00      312.00      110.00      30.00      70.00
1996.00      1.00      2.00      1400.00      667.00      110.00      30.00      70.00
1996.00      1.00      3.00      800.00       453.00      110.00      30.00      70.00
1996.00      1.00      4.00      750.00      1129.00      110.00      30.00      70.00
1996.00      1.00      5.00      950.00      556.00      110.00      30.00      70.00
1996.00      1.00      6.00     1080.00     1184.00      110.00      30.00      70.00
1996.00      1.00      7.00     1470.00      231.00      110.00      30.00      70.00
1996.00      1.00      8.00     2100.00      570.00      110.00      30.00      70.00
1996.00      1.00      9.00     1960.00     1368.00      110.00      30.00      70.00
1996.00      1.00     10.00     1430.00     1336.00      110.00      30.00      70.00
1996.00      2.00      1.00     1150.00      219.00      110.00      50.00      60.00
1996.00      2.00      2.00     1550.00      451.00      110.00      50.00      60.00
1996.00      2.00      3.00      950.00      407.00      110.00      50.00      60.00
    
```

Figure 8-54 Part of a Multi-Replicate Streamflow File

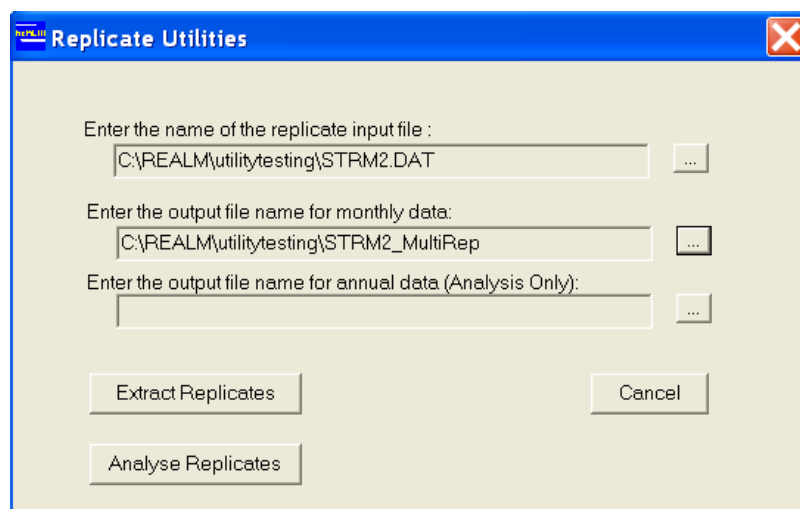


Figure 8-55 Replicate Utilities Dialog Box

8.7.1 REPLICATE EXTRACTION

Enter the input filename and the output filenames. The output filename for annual data is optional for replicate extraction and an output file by this filename will not be created with the Replicate Analysis utility, unless Replicate Analysis (Section 8.7.2) is performed. **Therefore, the output from the replicate extraction is stored in the output filename for monthly data.** Click on the 'Extract Replicates' button, which displays the Figure 8-56, allowing the user to select options for replicate extraction. Three options exist as follows:

1. One replicate at all sites
2. All replicates at one site
3. One replicate at one site.

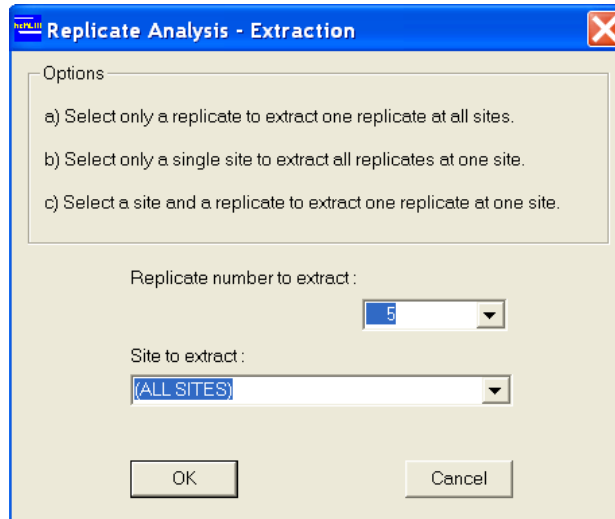


Figure 8-56 Replicate Extraction Dialog Box (Showing the selection of one replicate at all sites)

8.7.1.1 ONE REPLICATE AT ALL SITES

Select the required replicate number to extract (5 in Figure 8-58) and (ALL SITES), as in Figure 8-56 and click **OK**. This displays the output file (Figure 8-57 shows a part of the output file) corresponding to the selection in Figure 8-56 and input data file of Figure 8-54.

```

XTRCT
REALM
GETTING STARTED - TUTORIAL EXAMPLE
STREAMFLOW DATA
Data for: Replicate 5
( 8f12.2 )
8
YEAR
SEASON
REPLICATE
INFLOW1
INFLOW2
CLINX
RAIN
EVAP
1996.00 1.00 5.00 950.00 556.00 110.00 30.00 70.00
1996.00 2.00 5.00 880.00 371.00 110.00 50.00 60.00
1996.00 3.00 5.00 460.00 480.00 105.00 60.00 50.00
1996.00 4.00 5.00 1880.00 444.00 100.00 70.00 40.00
1996.00 5.00 5.00 4860.00 682.00 100.00 75.00 35.00
1996.00 6.00 5.00 8020.00 739.00 90.00 90.00 25.00
1996.00 7.00 5.00 14780.00 2103.00 90.00 95.00 10.00
1996.00 8.00 5.00 15800.00 9974.00 100.00 90.00 25.00
1996.00 9.00 5.00 14890.00 9315.00 105.00 80.00 35.00
1996.00 10.00 5.00 11050.00 5325.00 105.00 50.00 50.00
1996.00 11.00 5.00 7850.00 3478.00 110.00 50.00 50.00
1996.00 12.00 5.00 2330.00 2000.00 115.00 40.00 60.00
1997.00 1.00 5.00 1080.00 1184.00 110.00 30.00 70.00
1997.00 2.00 5.00 780.00 570.00 110.00 50.00 60.00
    
```

Figure 8-57 Multi-Replicate Output File Showing Data for All Data Columns of One Replicate

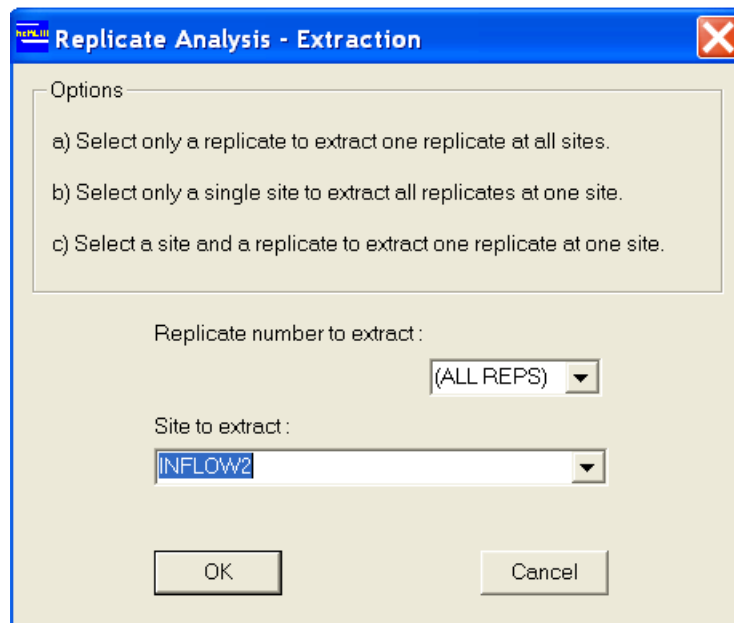


Figure 8-58 Replicate Extraction Dialog Box Showing the Selection of All Replicates at One Site

8.7.1.2 ALL REPLICATES AT ONE SITE

Select (ALL REPS) and the site to extract (INFLOW2 in Figure 8-58), as in Figure 8-58 and click **OK**. This displays an additional dialog box (Figure 8-59) for the user to select the output as one column per replicate or all replicates in one column. Tick the appropriate selection. In Figure 8-59, the 'One column per replicate' option is selected. Click **OK** to display the output file corresponding to this selection. A part of the output file is shown in Figure 8-60, which corresponds to the selection in Figure 8-59 and input data file of Figure 8-54.

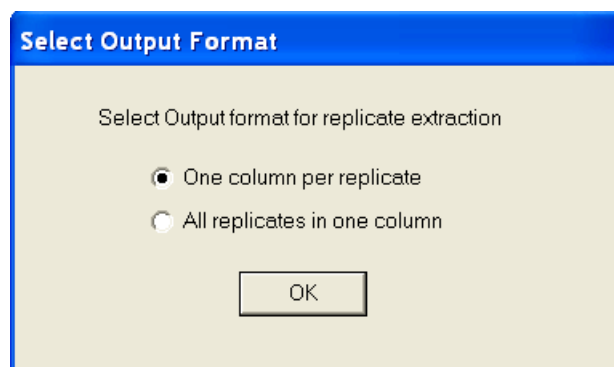


Figure 8-59 Select Output Format for Replicate Extraction of One Column and One Replicate

If the user selects the output format of 'All replicates in one column' option, the output file similar to Figure 8-61 is displayed. As in Figure 8-60, a part of the output file is shown in Figure 8-61.

```

XTRCT
REALM
GETTING STARTED - TUTORIAL EXAMPLE
STREAMFLOW DATA
Data for: INFLOW2
( 12f12.2          )
  12
SEASON
YEAR
INFLOW2  Repl:  1
INFLOW2  Repl:  2
INFLOW2  Repl:  3
INFLOW2  Repl:  4
INFLOW2  Repl:  5
INFLOW2  Repl:  6
INFLOW2  Repl:  7
INFLOW2  Repl:  8
INFLOW2  Repl:  9
INFLOW2  Repl: 10
1.00    1996.00    312.00    667.00    453.00    1129.00    556.00    1184.00    231.00    570.00    1368.00    1336.00
2.00    1996.00    219.00    451.00    407.00    567.00    371.00    570.00    57.00    527.00    709.00    867.00
3.00    1996.00    202.00    302.00    357.00    423.00    480.00    493.00    104.00    945.00    1017.00    668.00
4.00    1996.00    175.00    256.00    420.00    586.00    444.00    463.00    349.00    1359.00    2052.00    747.00
    
```

Figure 8-60 Part of a Multi-Replicate Output File Showing Data of One Column for All Replicates – One Column per Replicate

```

XTRCT
REALM
GETTING STARTED - TUTORIAL EXAMPLE
STREAMFLOW DATA
Data for Replicate   5, Site : INFLOW2
( 8f12.2             )
4
REPLICATE
SEASON
YEAR
INFLOW2
5.00      1.00      1996.00      556.00
5.00      2.00      1996.00      371.00
5.00      3.00      1996.00      480.00
5.00      4.00      1996.00      444.00
5.00      5.00      1996.00      682.00
5.00      6.00      1996.00      739.00
5.00      7.00      1996.00     2103.00
5.00      8.00      1996.00     9974.00
5.00      9.00      1996.00     9315.00
5.00     10.00     1996.00     5325.00
5.00     11.00     1996.00     3478.00
5.00     12.00     1996.00     2000.00
5.00      1.00     1997.00     1184.00
5.00      2.00     1997.00      570.00
5.00      3.00     1997.00      493.00
5.00      4.00     1997.00      463.00
5.00      5.00     1997.00      467.00
5.00      6.00     1997.00      454.00
5.00      7.00     1997.00      758.00
5.00      8.00     1997.00     2330.00
5.00      9.00     1997.00     2930.00
5.00     10.00     1997.00     1465.00
5.00     11.00     1997.00      696.00
5.00     12.00     1997.00      454.00
5.00      1.00     1998.00      231.00
5.00      2.00     1998.00       57.00
5.00      3.00     1998.00      104.00
5.00      4.00     1998.00      349.00
5.00      5.00     1998.00     1723.00
5.00      6.00     1998.00     4860.00
5.00      7.00     1998.00     6041.00
5.00      8.00     1998.00     7246.00
5.00      9.00     1998.00     3214.00
5.00     10.00     1998.00     2814.00
5.00     11.00     1998.00     1578.00
5.00     12.00     1998.00      979.00
5.00      1.00     1999.00      570.00
5.00      2.00     1999.00      527.00
5.00      3.00     1999.00      945.00
5.00      4.00     1999.00     1359.00
5.00      5.00     1999.00     4352.00
5.00      6.00     1999.00     5144.00
5.00      7.00     1999.00     4315.00
5.00      8.00     1999.00     3258.00
5.00      9.00     1999.00     4245.00
5.00     10.00     1999.00     2559.00
5.00     11.00     1999.00     1250.00
5.00     12.00     1999.00     1307.00
5.00      1.00     2000.00     1368.00
5.00      2.00     2000.00      709.00
5.00      3.00     2000.00     1017.00
5.00      4.00     2000.00     2052.00
5.00      5.00     2000.00     5854.00
5.00      6.00     2000.00     7143.00
5.00      7.00     2000.00     3615.00
5.00      8.00     2000.00     6930.00
5.00      9.00     2000.00     5748.00
5.00     10.00     2000.00     2447.00
5.00     11.00     2000.00     1689.00
5.00     12.00     2000.00     1250.00
5.00      1.00     2001.00     1336.00
5.00      2.00     2001.00      867.00
5.00      3.00     2001.00      668.00
5.00      4.00     2001.00      747.00
5.00      5.00     2001.00     1907.00
5.00      6.00     2001.00     3828.00
5.00      7.00     2001.00     2773.00
    
```

Figure 8-62 Part of a Multi-Replicate Output File Showing Data of One Replicate at One Site

8.7.2 REPLICATE ANALYSIS

Enter the input filename and the output filenames as in Figure 8-63. The monthly

and annual statistics will then be stored under the output filenames for monthly and annual data respectively. Click on the 'Analyse Replicates' button, which displays Figure 8-64, which allows the user to select options for replicate analysis in computing statistics.

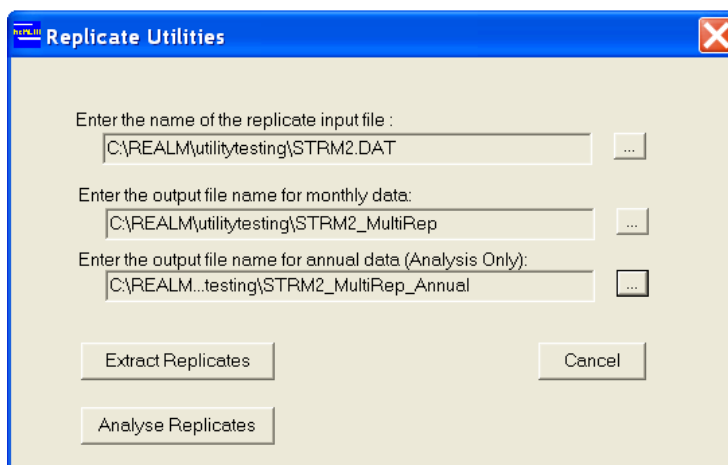


Figure 8-63 Replicate Utilities Dialog Box with Input and Output Files Entered to Compute Replicate Statistics

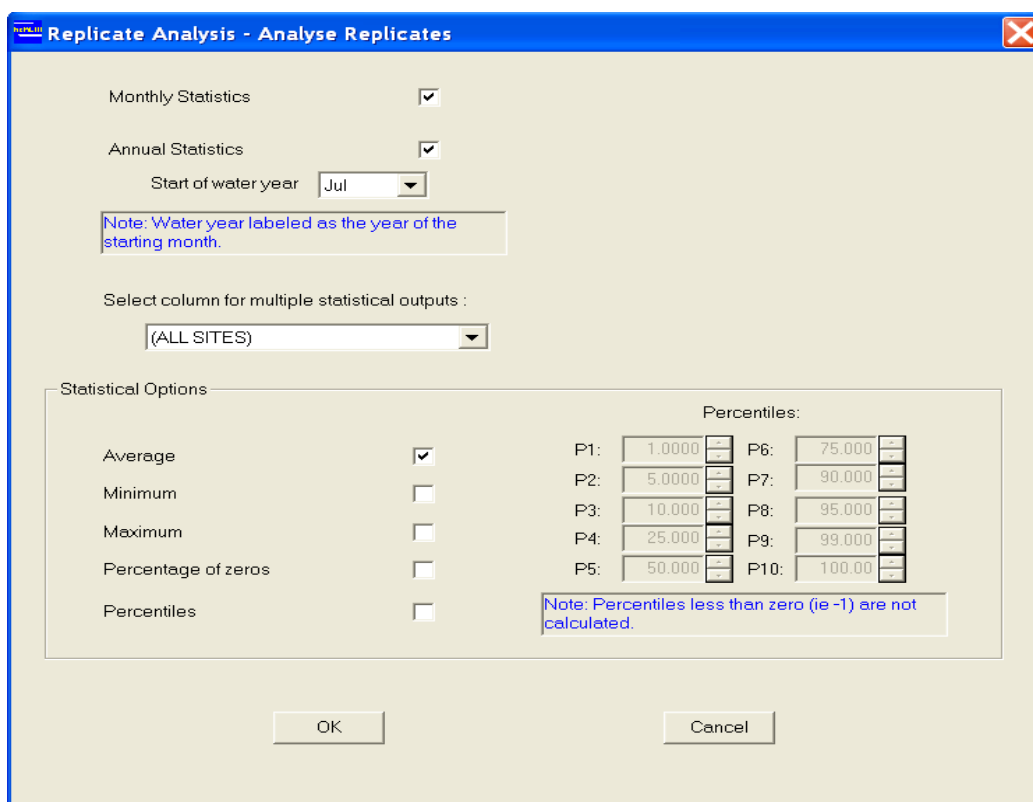


Figure 8-64 Replicate Analysis – Analyse Replicates Dialog Box

As can be seen from Figure 8-64, either monthly or annual statistics or both can be selected from Figure 8-64 and computed with respect to multiple replicates. When 'Annual Statistics' is selected, it is also necessary to enter the 'Start of water year'. If the 'Start of water year' is a month other than January, then the years in the annual output file are defined as below for an example of an input file, which has replicate data from 1996 to 2014.

1995	-	Jan 1996 - Jun 1996
1996	-	Jul 1996 - Jun 1997
1997	-	Jul 1997 - Jun 1998
...
2013	-	Jul 2013 - Jun 2014
2014	-	Jul 2014 - Dec 2014

Select the required options for computing statistics (i.e. monthly, annual or both). For both monthly and annual statistics options, either ALL SITES or a particular site (i.e. a column of data from the input file) can be selected. If ALL SITES is selected, only one statistic from Average, Minimum, Maximum, Percentage of zeros and Percentiles can be selected, and then the output for both monthly and annual statistics will contain only this statistic for ALL SITES. On the other hand, if a column of data (or one site) is selected, the user can select any number of statistics from the list of Average, Minimum, Maximum, Percentage of zeros and Percentiles, and then the output for both monthly and annual statistics will contain the selected statistics for the selected site. If Percentiles is selected, the user is able to specify the values of Percentiles P1 to P10.

Enter the selection as required and press **OK**. This will create the requested output files. **Cancel** will take the user back to Replicate Utilities Dialog box of Figure 8-63.

A part of the monthly statistics output file showing the average of replicates for ALL SITES is shown in Figure 8-65. In this case, ALL SITES and Average have been selected in Figure 8-64 and the input data file of Figure 8-54 has been used. The corresponding annual statistics file is shown in Figure 8-66. However, in this case 'Start of water year' has been selected as July. The file contents will be similar for the other statistics (i.e. Minimum, Maximum, Percentage of zeros and Percentiles P1 to P10) in both monthly and annual output files.

```

AVEG
REALM
GETTING STARTED - TUTORIAL EXAMPLE
MONTHLY STATISTICS FROM MONTHLY REPS
Time 06:05      Date 31/10/2005
( 7f12.2      )
  7
YEAR
SEASON
INFLOW1
INFLOW2
CLINX
RAIN
EVAP
1996.00      1.00      1319.00      780.60      110.00      30.00      70.00
1996.00      2.00      1281.00      474.50      110.00      50.00      60.00
1996.00      3.00      1072.00      499.10      105.00      60.00      50.00
1996.00      4.00      2110.00      685.10      100.00      70.00      40.00
1996.00      5.00      4045.00      1768.10      100.00      75.00      35.00
1996.00      6.00      8572.00      2658.20      90.00      90.00      25.00
1996.00      7.00      12185.00      3647.10      90.00      95.00      10.00
1996.00      8.00      15816.00      5194.30      100.50      90.00      25.00
1996.00      9.00      13323.00      4529.80      105.00      80.00      35.00
1996.00      10.00      9382.00      3794.00      105.50      52.00      49.00
1996.00      11.00      5154.00      3463.60      110.00      50.00      50.00
1996.00      12.00      3047.80      1424.70      115.00      40.00      60.00
1997.00      1.00      1296.00      900.10      110.00      30.00      70.00
1997.00      2.00      1253.00      725.70      110.00      50.00      60.00
1997.00      3.00      1037.00      634.50      105.00      60.00      50.00
1997.00      4.00      2107.00      769.20      100.00      70.00      40.00
1997.00      5.00      3986.00      1787.70      100.00      75.00      35.00
1997.00      6.00      7960.00      2631.90      90.00      90.00      25.00
1997.00      7.00      12064.00      3629.80      90.00      95.00      10.00
1997.00      8.00      15698.00      5040.30      100.50      90.00      25.00
1997.00      9.00      13128.00      4598.60      105.00      80.00      35.00
1997.00      10.00      9361.00      3720.80      105.50      50.00      50.00
1997.00      11.00      5036.00      3401.60      110.00      50.00      50.00
1997.00      12.00      2132.00      1394.00      115.00      40.00      60.00
1998.00      1.00      1228.00      872.40      110.00      30.00      70.00
1998.00      2.00      1143.00      883.80      110.00      50.00      60.00
1998.00      3.00      946.00      716.60      105.00      60.00      50.00
1998.00      4.00      1996.00      873.90      100.00      70.00      40.00
1998.00      5.00      3765.00      1892.00      100.00      75.00      35.00
1998.00      6.00      7484.00      2896.50      90.00      90.00      25.00
1998.00      7.00      11486.00      3538.60      90.00      95.00      10.00

```

Figure 8-65 Monthly Statistics Output File Showing Average of Multiple Replicate Data for ALL SITES

A part of the monthly statistics output file showing the average, the minimum and the maximum of replicates for the column INFLOW2 is shown in Figure 8-67. In this case, column INFLOW2 and Average, Minimum and Maximum have been selected in Figure 8-64 and the input data file of Figure 8-54 has been used. The corresponding annual statistics file is shown in Figure 8-68. However, in this case 'Start of water year' has been selected as July. The file contents will be similar for the other statistics (i.e. Percentage of zeros and Percentiles P1 to P10) in both monthly and annual output files.


```

AVEG
REALM
GETTING STARTED - TUTORIAL EXAMPLE
ANNUAL STATISTICS FROM MONTHLY REPS (1st MONTH WATER YEAR= 7 )
Time 06:05      Date 31/10/2005
( 6f12.2      )
6
YEAR
INFLOW1
INFLOW2
CLINX
RAIN
EVAP
1995.00      3066.50      1144.27      102.50      62.50      46.67
1996.00      6378.90      2458.55      103.42      65.17      42.42
1997.00      6165.08      2493.36      103.42      65.00      42.50
1998.00      5963.33      2858.23      103.42      65.00      42.50
1999.00      5755.42      3020.48      103.42      65.00      42.50
2000.00      5588.25      3251.19      103.42      65.00      42.50
2001.00      5410.33      3252.35      103.42      65.00      42.50
2002.00      5246.28      3364.93      103.42      65.00      42.50
2003.00      5025.37      3478.93      103.33      65.00      42.50
2004.00      4807.78      3432.91      103.33      65.00      42.50
2005.00      4773.87      3346.88      103.33      65.00      42.50
2006.00      4978.53      3293.88      103.33      65.00      42.50
2007.00      5260.12      3171.68      103.33      65.00      42.50
2008.00      5467.78      2944.94      103.33      65.00      42.50
2009.00      5576.37      2829.38      103.33      65.00      42.50
2010.00      5606.62      2586.08      103.33      65.00      42.50
2011.00      5543.37      2711.84      103.33      65.00      42.50
2012.00      5549.42      2814.46      103.33      65.00      42.50
2013.00      5655.73      2859.37      103.33      65.00      42.50
2014.00      8629.13      5085.87      104.17      67.50      38.33
    
```

Figure 8-66 Annual Statistics Output File Showing Average of Multiple Replicate Data for ALL SITES

```

REPS
REALM
GETTING STARTED - TUTORIAL EXAMPLE
MONTHLY STATISTICS FROM MONTHLY REPS
Time 06:05      Date 31/10/2005
( 5f12.2      )
  5
YEAR
SEASON
INFLOW2      AVEG
INFLOW2      MINM
INFLOW2      MAXM
1996.00      1.00      780.60      231.00      1368.00
1996.00      2.00      474.50      57.00      867.00
1996.00      3.00      499.10      104.00     1017.00
1996.00      4.00      685.10      175.00     2052.00
1996.00      5.00      1768.10     467.00     5854.00
1996.00      6.00      2658.20     454.00     7143.00
1996.00      7.00      3647.10     758.00     6041.00
1996.00      8.00      5194.30     2330.00    9974.00
1996.00      9.00      4529.80     1870.00    9315.00
1996.00     10.00     3794.00     1465.00    8456.00
1996.00     11.00     3463.60     696.00    18893.00
1996.00     12.00     1424.70     454.00    2833.00
1997.00      1.00      900.10      231.00     1507.00
1997.00      2.00      725.70      57.00     2731.00
1997.00      3.00      634.50      104.00    1556.00
1997.00      4.00      769.20      256.00    2052.00
1997.00      5.00     1787.70     467.00    5854.00
1997.00      6.00     2631.90     454.00    7143.00
1997.00      7.00     3629.80     758.00    6041.00
1997.00      8.00     5040.30     2161.00   9974.00
1997.00      9.00     4598.60     2558.00   9315.00
1997.00     10.00     3720.80     1465.00   8456.00
1997.00     11.00     3401.60     696.00   18893.00
1997.00     12.00     1394.00     454.00   2833.00
1998.00      1.00      872.40      231.00     1507.00
1998.00      2.00      883.80      57.00     2731.00
1998.00      3.00      716.60      104.00    1556.00
1998.00      4.00      873.90      349.00    2052.00
1998.00      5.00     1892.00     467.00    5854.00
1998.00      6.00     2896.50     454.00    7143.00
1998.00      7.00     3538.60     758.00    6041.00
1998.00      8.00     5882.50     2161.00  11068.00
1998.00      9.00     5464.50     2558.00  11352.00
1998.00     10.00     4188.60     1465.00   9141.00
1998.00     11.00     3536.60     696.00  18893.00
1998.00     12.00     1481.80     454.00   2833.00
1999.00      1.00     1002.70     231.00     1756.00
1999.00      2.00      926.30      57.00     2731.00
1999.00      3.00      748.10      104.00    1556.00
1999.00      4.00      873.70      349.00    2052.00
1999.00      5.00     3472.40     467.00   16370.00
1999.00      6.00     3182.90     454.00    7143.00
1999.00      7.00     3911.90     758.00    9348.00
    
```

Figure 8-67 Monthly Statistics Output File Showing Average, Minimum and Maximum of Multiple Replicate Data for One Column

```

REPS
REALM
GETTING STARTED - TUTORIAL EXAMPLE
ANNUAL STATISTICS FROM MONTHLY REPS (1st MONTH WATER YEAR= 7 )
Time 06:05      Date 31/10/2005
( 4f12.2      )
  4
YEAR
INFLOW2      AVEG
INFLOW2      MINM
INFLOW2      MAXM
1995.00      1144.27      57.00      7143.00
1996.00      2458.55      57.00      18893.00
1997.00      2493.36      57.00      18893.00
1998.00      2858.23      57.00      18893.00
1999.00      3020.48      57.00      18893.00
2000.00      3251.19      57.00      18893.00
2001.00      3252.35      57.00      18893.00
2002.00      3364.93      320.00     18893.00
2003.00      3478.93      320.00     18893.00
2004.00      3432.91      320.00     18893.00
2005.00      3346.88      294.00     18893.00
2006.00      3293.88      256.00     16377.00
2007.00      3171.68      94.00      16377.00
2008.00      2944.94      94.00      16377.00
2009.00      2829.38      94.00      16377.00
2010.00      2586.08      94.00      15157.00
2011.00      2711.84      94.00      15157.00
2012.00      2814.46      94.00      15157.00
2013.00      2859.37      94.00      15157.00
2014.00      5085.87      415.00     16978.00

```

Figure 8-68 Annual Statistics Output File Showing Average, Minimum and Maximum of Multiple Replicate Data for One Column

8.8 LP DUMP

An LP dump is a useful output, which can be used to identify the problems when REALM does not produce a solution for flows in the water supply network. LP stands for Linear Program. REALM uses a Network Linear Programming algorithm called RELAX to solve the network. The LP dump contains information about nodes (names and inflows), carriers (names, from node, to node, penalty, capacity and flow) and iteration flags. The nodes include both physical (i.e. real) and system nodes. Carriers include physical carriers and system arcs. The system nodes and arcs are part of what is called ECNs - Equivalent Component Networks in REALM, which are used to convert the water supply system with physical nodes and carriers into a system of nodes and arcs, before solving this network using REALM. The reader is referred to the paper by Perera and James (2003) for the ECN concept of REALM.

The LP dump is part of the REALM log file. The utilities LP Solver (Section 8.9) and LP Extract (Section 8.10) can be used to analyse these LP dumps. The LP dumps are generated in two ways:

User Request:

The user can request an LP dump for a particular time step and replicate during the REALM simulation setup (Chapter 6). The output then contains LP data (or results) for each iteration of the requested time step and replicate. The user can then investigate how the solution progresses in nodes and carriers from one iteration to the next. After the dump, REALM continues with the simulation and produces all required output, as in a normal REALM run, including the summary information.

REALM uses an iterative procedure to solve the network for flows at a time step. Convergence of the solution is achieved through the tolerance limits specified in *realm.set*. The file *realm.set* is in the project directory.

Infeasible LP solution:

When an infeasible solution is detected, REALM dumps LP data into the log file. However, REALM then makes some adjustments to the network and solves again to produce a second dump. The simulation process then stops. The log file in this case does not include the summary information on nodes and carriers. The REALM format output files contain data up to (excluding) the current time step.

User Request LP Dump

A typical log file containing user-request LP dump is shown in Figure 8-69. In Figure 8-69, all the iterations are not shown, only the iterations 1, 2 and 5. This log file has been requested for replicate of February 1996. When the utilities LP Solver and LP Extract are used with the LP dump, they look for strings of "Arc Details" and "Node Details" in the dump (Figure 8-69). Therefore, the relative position of these strings is important in the dump file and the user should not change these positions before using these utilities.

The "Arc Details" contain the following information:

Arc number

Arc name

From node

To node

Arc penalty

Arc capacity

Arc flow

Arc number (again).

Note that the "Arc Details" contains the above information for both physical and system arcs (denoted by ECN).

The "Node Details" contain the following information:

Node number

Node name

Nodal inflow

Node number (again).

Again the "Node Details" contains the above information for both physical nodes and system nodes (denoted by the ECN nodes).

```
HHHHH      HHHHHHHH      HHHHHH      H      HHHHHHHHHHH
H  H  H  H  H  H  H  H  H  H  H  H  H  H  H  H  H  H  H
HHHHHHHHH  HHHHHH      HHHHHHHH  HHH  HHH  H  H
HHH  H  HHH      HHH  H  HHH      HHH  H  H
HHH  H  HHH      HHH  H  HHH      HHH  H  H
HHH  H  HHHHHHHH  HHH  H  HHHHHHHH  HHH  H  H
```

```
*****
*      SIMULATION LOG FILE      *
*****
```

Log filename : Test.log

Scenario file: scenario.scn

Simulation label:
REALM Getting Started Problem

Streamflow file(s):
C:\REALM\GetStart\Test LP Dump\Strml.dat
Demand file(s):
C:\REALM\GetStart\Test LP Dump\demd.dat

Restrictions are ON

Instream flow requirements NOT limited to natural
Water quality calculations are OFF

Number of S/F Sequences: 1

Convergence tolerance (storage) 1 10th%
Other convergence tolerance 5 %
Arc convergence tolerance (abs) 100
Minimum iteration count 3
Maximum iteration count 51
Do convergence twice No

Date: 05:49:17 15/10/05

Time Step = Monthly

SYSTEM CHANGES:

```
No      Seas  Year  System File
-----
 1       1  1996  C:\REALM\GetStart\Test LP Dump\tut.sys
-----
```

Total number of seasons:- 336

***** RUN TIME MESSAGES:- *****

****INPUT DATA TYPE= 2 ****

1996

C:\REALM\GetStart\Test LP Dump\tut.sys

Iteration No = 1
 Seas = 2 Year = 1996 Repl = 1

Arc Details

1 RES A TO ST-A	1	4	1000	0	0	1
2 RES B TO ST-B	2	5	1000	0	0	2
3 RES A TO CITY	1	3	1	0	0	3
4 RES B TO CITY	2	3	1	0	0	4
5 RESERVOIR CONNECTOR	1	2	50	100	100	5
6 Reservoir Ecn	1	6	501000	49284	8777	6
7 Reservoir Ecn	6	1	101000	50716	0	7
8 Reservoir Ecn	1	6	3100000	100000000	0	8
9 Reservoir Ecn	6	1	60000000	0	0	9
10 Reservoir Ecn	2	6	500000	19998	0	10
11 Reservoir Ecn	6	2	102000	40002	621	11
12 Reservoir Ecn	2	6	3100000	100000000	0	12
13 Reservoir Ecn	6	2	60000000	0	0	13
14 Demand Ecn	7	3	50001000	8843	8843	14
15 Demand Ecn	4	6	2000000	100000000	0	15
16 Demand Ecn	5	6	2000000	100000000	0	16
17 Losses Ecn	6	4	55000010	100000000	0	17
18 Losses Ecn	6	5	55000020	100000000	0	18
19 Losses Ecn	6	3	55000030	100000000	1226	19
20 Losses Ecn	6	3	55000040	100000000	0	20
21 Losses Ecn	6	2	55000050	100000000	0	21
22 Bypass Ecn	6	7	0	100000000	8843	22

Node Details

```

1 RESERVOIR A          8877  1
2 RESERVOIR B         -721  2
3 CITY                -10069 3
4 STRM TERM A         0    4
5 STRM TERM B         0    5
6 Ecn Node            1913  6
7 Ecn Node            0    7
0 (=sum of node requirements)

Iteration Flags
-----
DO_FF_AGAIN = Y
DO_S_AGAIN  = N
DO_L_AGAIN  = Y
DO_B_AGAIN  = Y
DO_CS_AGAIN = n
DO_AT_LEAST_AGAIN = Y
DO_GD_CAP_AGAIN = N
Redo Loss: Carrier RESERVOIR CONNECTOR arc = 5 ( 6777.00000 %)
Redo Balance: Convergence 8.19999981 %

Iteration No = 2
Seas = 2 Year = 1996 Repl = 1

Arc Details

1 RES A TO ST-A      1  4    1000      0      0  1
2 RES B TO ST-B      2  5    1000      0      0  2
3 RES A TO CITY      1  3      1    4422    4422  3
4 RES B TO CITY      2  3      1   30692   4421  4
5 RESERVOIR CONNECTOR 1  2      50    6078   6078  5
6 Reservoir Ecn      1  6   501000  45885      0  6
7 Reservoir Ecn      6  1   101000  54115   5022  7
8 Reservoir Ecn      1  6  3100000 100000000      0  8
9 Reservoir Ecn      6  1  60000000      0      0  9
10 Reservoir Ecn     2  6   500000   15241      0 10
11 Reservoir Ecn     6  2   102000  44759   3144 11
12 Reservoir Ecn     2  6  3100000 100000000      0 12
13 Reservoir Ecn     6  2  60000000      0      0 13
14 Demand Ecn        7  3  50001000   8843      0 14
15 Demand Ecn        4  6   2000000 100000000      0 15
16 Demand Ecn        5  6   2000000 100000000      0 16
17 Losses Ecn        6  4  55000010 100000000      0 17
18 Losses Ecn        6  5  55000020 100000000      0 18
19 Losses Ecn        6  3  55000030 100000000      0 19
20 Losses Ecn        6  3  55000040 100000000      0 20
21 Losses Ecn        6  2  55000050 100000000      0 21
22 Bypass Ecn        6  7      0 100000000      0 22

```

Node Details

1 RESERVOIR A	5478	1
2 RESERVOIR B	-4801	2
3 CITY	-8843	3
4 STRM TERM A	0	4
5 STRM TERM B	0	5
6 Ecn Node	8166	6
7 Ecn Node	0	7
	0	(=sum of node requirements)

Iteration Flags

```

-----
DO_FF_AGAIN = Y
DO_S_AGAIN  = N
DO_L_AGAIN  = Y
DO_B_AGAIN  = Y
DO_CS_AGAIN = n
DO_AT_LEAST_AGAIN = Y
DO_GD_CAP_AGAIN = N
Redo Vol Dep: Carrier RES B TO CITY      arc = 4      ( 100.000000 %)
Redo Loss: Carrier RES B TO CITY        arc = 4      ( 100.000000 %)
Redo Balance: Convergence 9.00000000 %

```

. . .
. . .
. . .

Iteration No = 5
Seas = 2 Year = 1996 Repl = 1

Arc Details

1 RES A TO ST-A	1	4	1000	0	0	1
2 RES B TO ST-B	2	5	1000	0	0	2
3 RES A TO CITY	1	3	1	4422	4422	3
4 RES B TO CITY	2	3	1	30692	5402	4
5 RESERVOIR CONNECTOR	1	2	50	6078	5081	5
6 Reservoir Ecn	1	6	501000	49905	0	6
7 Reservoir Ecn	6	1	101000	50095	5	7
8 Reservoir Ecn	1	6	3100000	10000000	0	8
9 Reservoir Ecn	6	1	60000000	0	0	9
10 Reservoir Ecn	2	6	500000	20868	0	10
11 Reservoir Ecn	6	2	102000	39132	0	11
12 Reservoir Ecn	2	6	3100000	10000000	0	12
13 Reservoir Ecn	6	2	60000000	0	0	13
14 Demand Ecn	7	3	50001000	8843	0	14
15 Demand Ecn	4	6	2000000	10000000	0	15
16 Demand Ecn	5	6	2000000	10000000	0	16

17 Losses Ecn	6	4	55000010	100000000	0	17
18 Losses Ecn	6	5	55000020	100000000	0	18
19 Losses Ecn	6	3	55000030	100000000	0	19
20 Losses Ecn	6	3	55000040	100000000	0	20
21 Losses Ecn	6	2	55000050	100000000	0	21
22 Bypass Ecn	6	7	0	100000000	0	22
Node Details						
1 RESERVOIR A	9498	1				
2 RESERVOIR B	321	2				
3 CITY	-9824	3				
4 STRM TERM A	0	4				
5 STRM TERM B	0	5				
6 Ecn Node	5	6				
7 Ecn Node	0	7				
	0	(=sum of node requirements)				
Iteration Flags						

DO_FF_AGAIN = N						
DO_S_AGAIN = N						
DO_L_AGAIN = N						
DO_B_AGAIN = N						
DO_CS_AGAIN = n						
DO_AT_LEAST_AGAIN = N						
DO_GD_CAP_AGAIN = N						
1997						
1998						
1999						
2000						
2001						
2002						
2003						
2004						
2005						
2006						
2007						
2008						
2009						
2010						
2011						
2012						
2013						
2014						
2015						
2016						
2017						
2018						

```

2019
2020
2021
2022
2023
***** END RUN TIME MESSAGES *****

SUMMARY INFORMATION

Reservoir data:

      Name          Start   File   Min   Average   Evapn   Release   Spill   End
      Storage      Inflow  Storage Storage   Storage to river  Storage
1  RESERVOIR A      70000.  5672.  45682.  80290.   -182.    0.    1105.  93294.
2  RESERVOIR B      40000.  2984.  32961.  58581.    0.    0.    864.  60000.
-----
                        110000.  8656.    0.  138872.  -182.    0.    1969.  153294.
-----

Demand data:

      Name          Unrestrict  Restrict  Rationed  Shortfall  Supplied
1  CITY            5880.    5880.    5880.     0.    5880.
-----
                        5880.    5880.    5880.     0.    5880.
-----

      Name          No       Ave       Max       No       Ave %       Max %       No       Ave %       Max %
      Rest      Rest lvl  Rest lvl  Ration  Ration  Short  Short  Short  Short
1  CITY            0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
-----

Pipe/River flows:

      Name          flow      Capacity      Min      Max      Loss
1  RES A TO ST-A      0.0        0.0        0.0        0.0        0.0
2  RES B TO ST-B      0.0        0.0        0.0        0.0        0.0
3  RES A TO CITY     2489.8     2940.2        0.0     5528.0     248.5
4  RES B TO CITY     4038.0    43416.5    1837.0     6773.0     399.6
5  RESERVOIR CONNECTOR  2190.1     8554.3        0.0     7279.0     212.6
-----
                                                861.
-----

End run

```

Figure 8-69 Typical User Request LP Dump

The “Iteration Flags” shows whether the convergence has been achieved during that iteration in comparison with the previous iteration. Seven flags are listed in the dump and a Y next to at least one flag indicates that the solution has not converged and, therefore, REALM will undertake another iteration, unless the maximum iteration count is reached (which is separated by the user through the “Convergence/Iteration” tab of *Run::Options* - Section 4.4.7.3). In any case, REALM runs for a minimum number of iterations, which is also specified by the user through the “Convergence/Iteration” tab of *Run::Options* (Section 4.4.7.3). The minimum and the maximum iteration counts are stored in *realm.set* file in the project directory and also listed in the top part of the standard and dump log files. The seven flags (with their description) are as follows:

DO_FF_AGAIN	indicates whether or not capacity of variable capacity carriers have converged.
DO_S_AGAIN	indicates whether or not downstream spills from reservoirs have converged.
DO_L_AGAIN	indicates whether or not carrier losses have converged.
DO_B_AGAIN	indicates whether or not reservoir storage volumes have converged.
DO_CS_AGAIN	indicates whether or not capacity of capacity shared carriers have converged.
DO_AT_LEAST_AGAIN	indicates whether or not a minimum number of iterations has been reached
DO_GD_CAP_AGAIN	indicates whether or not capacity related to gravity diversion has converged (however, the facility to create gravity diversion nodes is no longer supported in REALM, although the facility exists to edit them).

If the solution has not converged, it also gives a hint on where it has not converged.

LP Dump created by an infeasible solution

When an infeasible solution occurs in REALM at a particular time step and a particular replicate, REALM dumps LP data (or results) for this time step and replicate. This LP dump can then be analysed to investigate the cause of the infeasible solution. Some causes for infeasible solutions are given below:

- A capacity constraint of a carrier that results in a ‘bottleneck’ in the system may cause an infeasible solution. If this is suspected, then examine carrier capacities, especially the variable capacity carriers. If the user is satisfied with these carriers, then check the carriers where flow equals capacity and see whether any of these carriers act as a ‘bottleneck’ carrier. This could be the case where a carrier connects to a stream terminator.

- Infeasible solutions are also generated when total inflows at a node are greater than total outflows. The outflows can be demands.

In the event of an infeasible solution, REALM generates the LP dump in two parts, the first part with physical nodes, system nodes, physical carriers and system arcs as in Figure 8-69, and the second part containing 'bottleneck' debug arcs. These bottleneck arcs effectively eliminate the bottlenecks and provide a solution. A flow in one of these arcs indicates that there is a bottleneck in the vicinity of this arc of the network. The users should therefore look for flows in the 'bottleneck arcs' as a starting point. Follow the network looking for physical carriers where flow equals the capacity in the vicinity of these arcs. Carefully examine all such carriers. Such a LP dump (which is created by REALM because of a bottleneck in the system) is shown in Figure 8-70.

```

      HHHHH      HHHHHHHH      HHHHHH      H      HHHHHHHHHH
      H  H      H      H  H      H      H  H  H
      HHHHHHHH      HHHHHH      HHHHHHHH      HHH      HHH  H  H
      HHH      H  HHH      HHH      H  HHH      HHH  H  H
      HHH      H  HHH      HHH      H  HHH      HHH  H  H
      HHH      H  HHHHHHHH      HHH      H  HHHHHHHH      HHH  H  H

      *****
      *      SIMULATION LOG FILE      *
      *****

Log filename : Test.log

Scenario file: scenariol.sc

Simulation label:
      REALM LP Dump created by an infeasible solution

Streamflow file(s):
      C:\REALM\GetStart\Test LP Dump\SF1.DAT
Demand file(s):
      C:\REALM\GetStart\Test LP Dump\DEM.DAT

Restrictions are ON

Instream flow requirements NOT limited to natural
      Water quality calculations are OFF

Number of S/F Sequences:      1

Convergence tolerance (storage)      1 10th%
Other convergence tolerance      5 %
Arc convergence tolerance (abs)      100
Minimum iteration count      3
Maximum iteration count      51
Do convergence twice      No

Date: 06:15:51 15/10/05

Time Step = Monthly

SYSTEM CHANGES:
No      Seas      Year      System File
-----
      1      1      1982      C:\REALM\GetStart\Test LP Dump\LPDump.sys
-----

Total number of seasons:-      36

***** RUN TIME MESSAGES:- *****

```

```

****INPUT DATA TYPE= 1 ****

1982
C:\REALM\GetStart\Test LP Dump\LPDump.sys
EXIT DURING INITIALIZATION
EXOGENOUS FLOW INTO NODE 1 EXCEEDS OUT CAPACITY
DEFICIT (I.E., NET FLOW OUT) OF NODE = -416
FLOWS AND CAPACITIES OF INCIDENT ARCS OF NODE 1
ARC 1 BETWEEN NODES 1 3
FLOW = 0
RESIDUAL CAPACITY = 100
NO INCOMING ARCS
INFEASIBLE LP SOLUTION. NSTOP = 16
SEAS= 1 YEAR= 1982 REPl= 1
Seas = 1 Year = 1982 Repl = 1

Arc Details

1 Pipe 1          1  3          0          100          0  1
2 Pipe 2          2  3          0          100          0  2
3 Pipe 3          3  5          0  99999999          0  3
4 River          3  4          0  99999999          0  4
5 Demand Ecn     7  5  50001000    2700          0  5
6 Demand Ecn     4  6  2000000  100000000          0  6
7 Bypass Ecn     6  7          0  100000000          0  7

Node Details

1 Strm Junction 1      416  1
2 Strm Junction 2      416  2
3 Strm Junction 3         0  3
4 Stream Terminator     0  4
5 DEMAND 1             -2700 5
6 Ecn Node              1868 6
7 Ecn Node               0  7
0 (=sum of node requirements)

This log file contains additional information
which may help to identify bottleneck
Seas = 1 Year = 1982 Repl = 1

Arc Details

1 Pipe 1          1  3          0          100          100  1
2 Pipe 2          2  3          0          100          100  2
3 Pipe 3          3  5          0  99999999          200  3
4 River          3  4          0  99999999          0  4
5 Demand Ecn     7  5  50001000    2700          2500 5
6 Demand Ecn     4  6  2000000  100000000          0  6
7 Bypass Ecn     6  7          0  100000000          2500 7
8 Bottleneck debug arc 1  6  90000000  99999999          316  8
9 Bottleneck debug arc 2  6  90000000  99999999          316  9
10 Bottleneck debug arc 3  6  90000000  99999999          0  10
11 Bottleneck debug arc 4  6  90000000  99999999          0  11
12 Bottleneck debug arc 6  5  90000000  99999999          0  12

Node Details

1 Strm Junction 1      416  1
2 Strm Junction 2      416  2
3 Strm Junction 3         0  3
4 Stream Terminator     0  4
5 DEMAND 1             -2700 5
6 Ecn Node              1868 6
7 Ecn Node               0  7
0 (=sum of node requirements)

```

Figure 8-70 Typical LP Dump Created by an Infeasible Solution

Often, the above process will show up some deficiency in the system description. Users should look at ways of re-setting the physical network to avoid the problem.

Re-run REALM after making such changes to see if the infeasible solution still exists. Alternatively, if the user suspects a particular carrier, run LP Solver after changing the capacity of this carrier to a large value in the log file. In this case, the log file is used as the input file in LP Solver (Section 8.9).

8.9 LP SOLVER

The utility LP Solver can be used in two ways, as follows:

- With a LP dump file generated by REALM as a result of an infeasible solution or with a LP dump file created as a result of the request of the user. These LP dump files are created as the log file.
- With an input file prepared by the user for a particular network.

In both cases, the dialog boxes for entering data are the same. However, in the former case, the input file is a REALM log file with LP dump information, while in the latter case, it is a user-prepared input file, which has the format of *template.lps* (stored *c:\realm\WorkedExamples* directory). In both cases, LP Solver attempts to solve the network considering user inputs on nodes and carriers/arcs, which can be edited when using LP Solver.

8.9.1 USE OF LP SOLVER WITH LP DUMP FILES CREATED BY AN INFEASIBLE SOLUTION

Figure 8-70 shows a log file, which was created as a result of an infeasible solution. This file is used as input to LP Solver in this example.

Select *Utilities::LP Solver*, which displays the “LP Solver” dialog box (Figure 8-71). This dialog box allows the user to enter the input filename (in this case the log filename) and the output filename. It also allows the user to edit node and carrier details in order to identify the cause of the infeasible solution. There is also the option to add a comment to describe the output.

Note that both the ‘*Edit Node Details*’ and the ‘*Edit Carrier Details*’ check boxes are ticked in Figure 8-71. Click **OK** in Figure 8-71, which displays the “LP Solver – Edit Nodes” dialog box (Figure 8-72). This dialog box allows the user to edit the information on ‘*Node Name*’ and ‘*Node Requirement*’ in order to identify the cause of the infeasible solution. As it can be seen from Figure 8-72 (and later from Figure 8-73), there are no iterations for the analysis. This is because the log file used (Figure 8-70) does not contain results for several iterations. Click on **Save and Exit** in Figure 8-72, which displays the “LP Solver – Edit Arcs” dialog box (Figure 8-73). This dialog box is similar to the “Edit Nodes” dialog box, except that the user can edit information in the fields ‘*Arc Name*’, ‘*From*’ (node), ‘*To*’ (node) ‘*Arc Cost*’ (or penalty) and ‘*Arc Capacity*’, again to facilitate the identification of the cause of the infeasible solution.

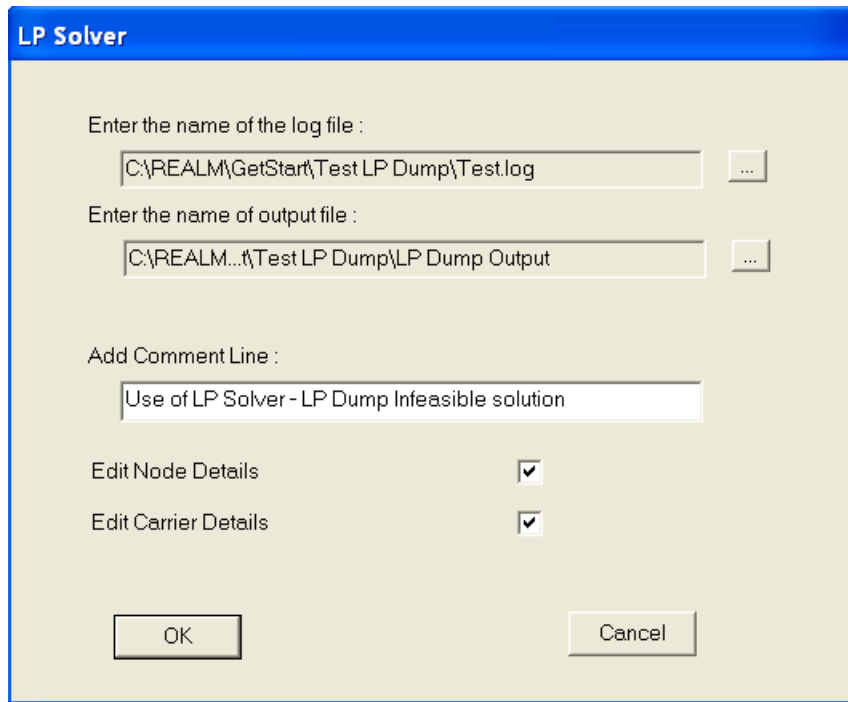


Figure 8-71 LP Solver Dialog Box

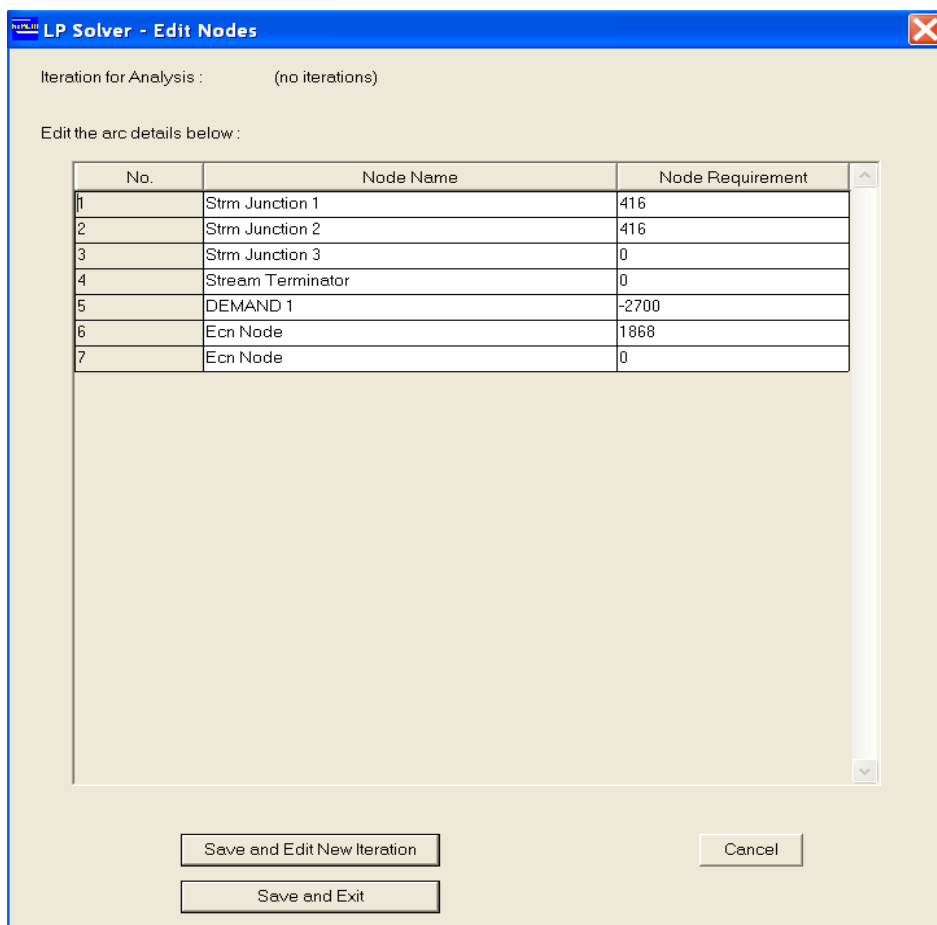


Figure 8-72 LP Solver - Edit Nodes Dialog Box

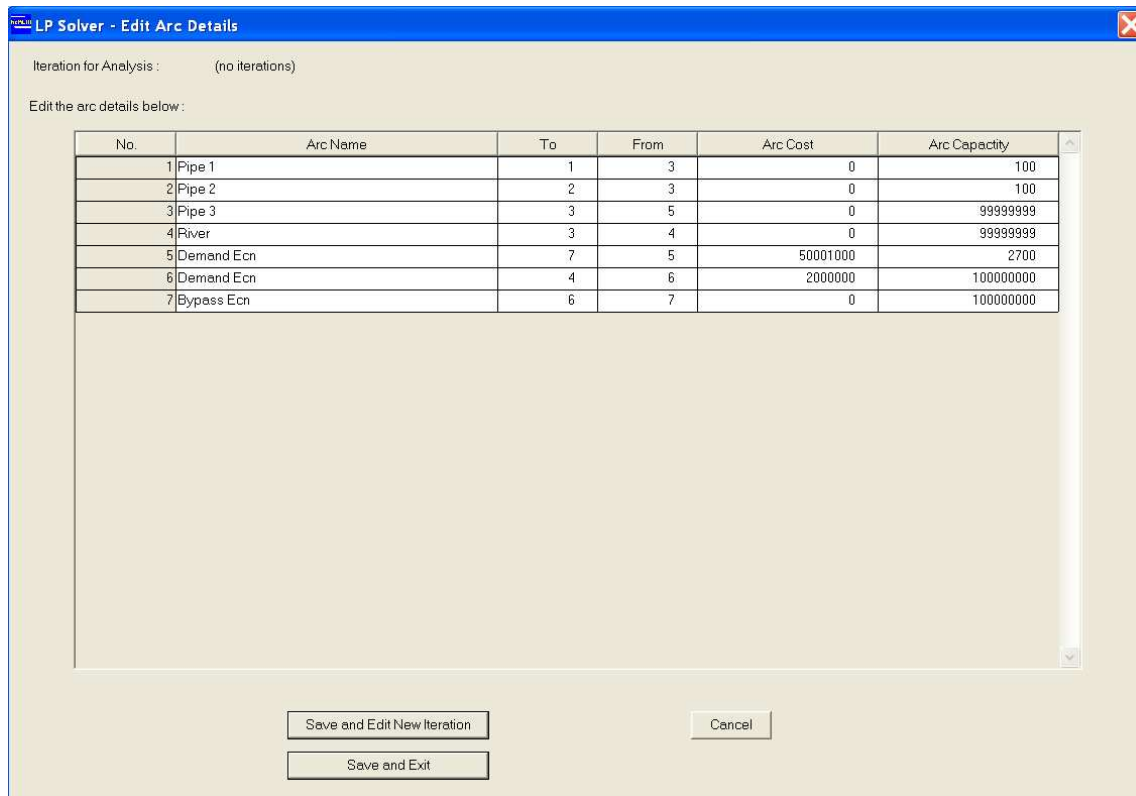


Figure 8-73 LP Solver – Edit Arcs Dialog Box

If the check boxes ‘*Edit Node Details*’ and ‘*Edit Carrier Details*’ are both ticked as in Figure 8-71, then the dialog boxes of Figure 8-72 and Figure 8-73 are displayed successively to edit node and carrier information. However, the user may want only to edit either nodes or carriers. In this case, the user can tick the appropriate check box to display either Figure 8-72 or Figure 8-73.

Click on **Save and Exit** in Figure 8-73. This will display the output file, as in Figure 8-74. This is the output file corresponding to Figure 8-70, without making any changes to node and arc details in Figure 8-71 and Figure 8-72. As expected, this has produced an infeasible solution, and it is shown with the comment “INFEASIBLE LP SOLUTION. NSTOP = 16”, as was in Figure 8-70. Both Figure 8-70 and Figure 8-74 are similar and give two sets of Node/Arc details, the second set with ‘diagnostic arcs’, which helps to identify the cause of the infeasible solution. Note that in the first set of Arc details in Figure 8-74 (and Figure 8-70), the flows (second last column) are not given, while in the second set, flows are given for a system created by LP Solver with additional “diagnostic arcs”. In particular, there are 2 diagnostic arcs from node 1 to node 8 (diagnostic arc 8) and from node 2 to node 8 (diagnostic arc 9) which have flows. This is an indication that there are ‘bottleneck’ carriers downstream of both nodes 1 and 2.

```

-----
R       E       A       L       M
-----
*****
* L P   S O L V E R   *
*****

File: C:\REALM\GetStart\Test LP Dump\Test.log

Date: 07:31    15/10/2005

Comment = Use of LP Solver - LP Dump Infeasible solution
INFEASIBLE LP SOLUTION. NSTOP = 16

Arc Details

  1 Pipe 1           1   3           0       100           0   1
  2 Pipe 2           2   3           0       100           0   2
  3 Pipe 3           3   5           0 99999999          0   3
  4 River            3   4           0 99999999          0   4
  5 Demand Ecn       7   5 50001000      2700           0   5
  6 Demand Ecn       4   6 2000000 100000000         0   6
  7 Bypass Ecn       6   7           0 100000000         0   7

Node Details

  1 Strm Junction 1      416   1
  2 Strm Junction 2      416   2
  3 Strm Junction 3         0   3
  4 Stream Terminator     0   4
  5 DEMAND 1              -2700  5
  6 Ecn Node              1868   6
  7 Ecn Node               0   7
                                0 (=sum of node requirements)

Solution with diagnostic arcs

Arc Details

  1 Pipe 1           1   3           0       100          100   1
  2 Pipe 2           2   3           0       100          100   2
  3 Pipe 3           3   5           0 99999999         200   3
  4 River            3   4           0 99999999          0   4
  5 Demand Ecn       7   5 50001000      2700         1868   5
  6 Demand Ecn       4   6 2000000 100000000         0   6
  7 Bypass Ecn       6   7           0 100000000         1868   7
  8 diagnostic arcs   1   8 90000000 99999999          316   8
  9 diagnostic arcs   2   8 90000000 99999999          316   9
 10 diagnostic arcs   3   8 90000000 99999999           0  10
 11 diagnostic arcs   4   8 90000000 99999999           0  11
 12 diagnostic arcs   8   5 90000000 99999999          632  12
 13 diagnostic arcs   6   8 90000000 99999999           0  13
 14 diagnostic arcs   7   8 90000000 99999999           0  14

Node Details

  1 Strm Junction 1      416   1
  2 Strm Junction 2      416   2
  3 Strm Junction 3         0   3
  4 Stream Terminator     0   4
  5 DEMAND 1              -2700  5
  6 Ecn Node              1868   6
  7 Ecn Node               0   7
  8                        0   8
                                0 (=sum of node requirements)

```

Figure 8-74 LP Solver Output Showing an Infeasible Solution

Run LP Solver again, but this time increasing the capacity of the ‘bottleneck’ carriers downstream of the nodes 1 and 2. This is done through the “LP Solver – Edit Arc Details” dialog box of Figure 8-75. Note that the ‘Arc Capacity’ has changed from 100 (Figure 8-73) to 1000 to eliminate the ‘bottleneck’. The output from LP Solver for the network with changed arc capacities is given in Figure 8-76. Note that Figure 8-76 has the comment “LP SOLUTION OK. NSTOP = 17”, which states that the solution has reached for the corrected network, which has increased capacities for the two ‘bottleneck’ carriers, “Pipe 1” and “Pipe 2”.

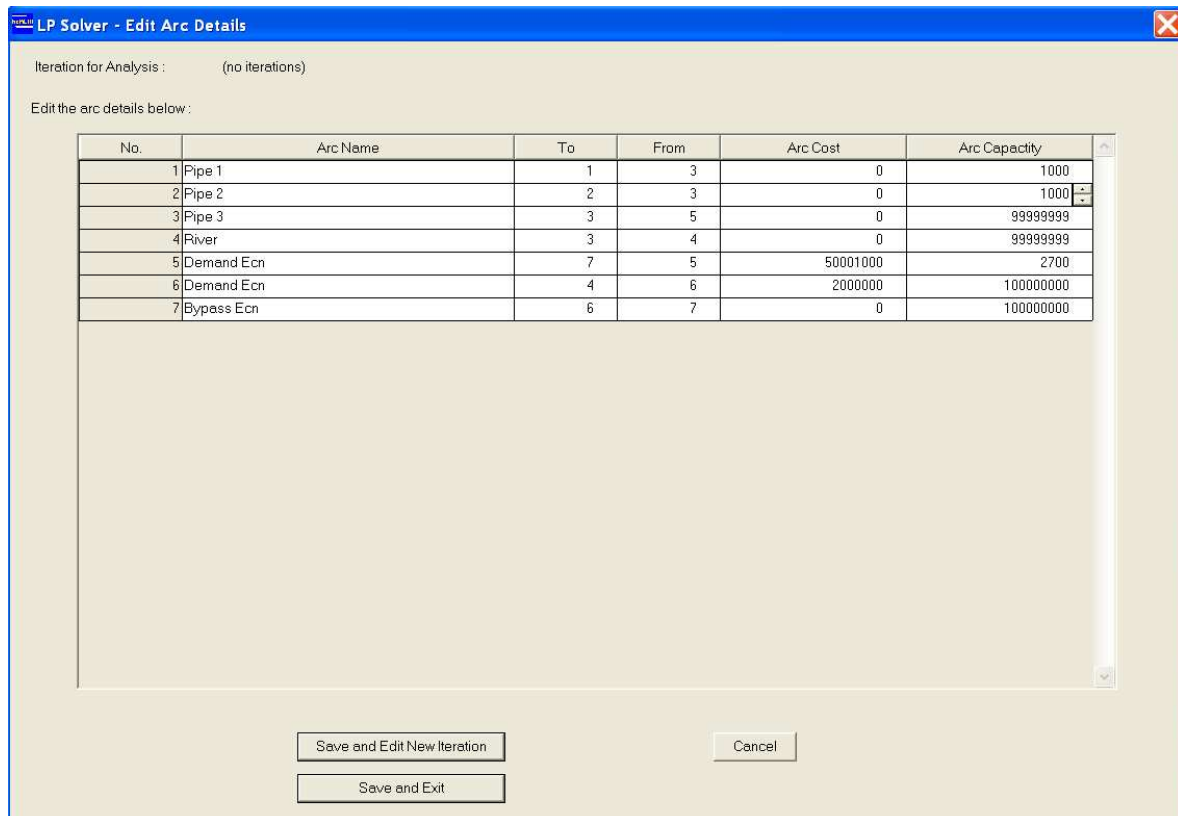


Figure 8-75 Changing Arc Capacity in LP Solver – Edit Arcs Dialog Box

```

R      E      A      L      M

*****
* L P   S O L V E R   *
*****

File: C:\REALM\GetStart\Test LP Dump\Test.log

Date: 07:37    15/10/2005

Comment = Use of LP Solver - LP Dump Infeasible solution
LP SOLUTION OK. NSTOP = 17

Arc Details

1 Pipe 1          1   3           0   1000       416   1
2 Pipe 2          2   3           0   1000       416   2
3 Pipe 3          3   5           0 99999999   832   3
4 River           3   4           0 99999999    0   4
5 Demand Ecn     7   5 50001000   2700     1868   5
6 Demand Ecn     4   6 2000000 100000000    0   6
7 Bypass Ecn     6   7           0 100000000  1868   7

Node Details

1 Strm Junction 1      416   1
2 Strm Junction 2      416   2
3 Strm Junction 3         0   3
4 Stream Terminator    0   4
5 DEMAND 1             -2700  5
6 Ecn Node              1868   6
7 Ecn Node              0   7
0 (=sum of node requirements)

```

Figure 8-76 LP Solver Output Showing a Feasible Solution

8.9.2 USE OF LP SOLVER WITH LP DUMP FILES CREATED BY USER REQUEST

When there is a warning message shown in the log file in relation to a convergence failure corresponding to a certain simulation time step and replicate, the user may request a LP dump for this time step and replicate during REALM Setup (Section 6.3.1). Then REALM produces a LP dump file (as the log file) during REALM simulation – similar to Figure 8-69 – which has results for the LP network iteration-by-iteration for this simulation time step and replicate.

LP Solver can then be used as previously to identify the cause of the warning message(s), although LP Extract (Section 8.9.3) is also commonly used for this purpose. However, if LP Solver is used, an additional dialog box, “LP Solver – Select Iteration”, (Figure 8-77) is displayed for the user to select the iteration for analysis, immediately after Figure 8-71.

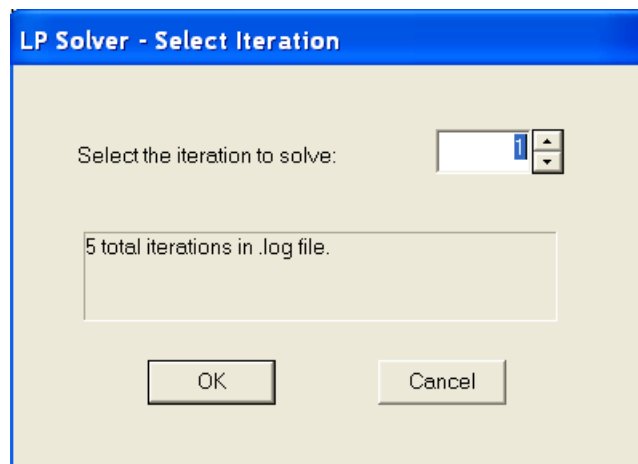


Figure 8-77 LP Solver – Select Iteration Dialog Box

Select the iteration (which had given the warning message) that requires analysis and click **OK**. This will display the appropriate dialog boxes (Figure 8-72 and/or Figure 8-73) for the user to edit node and/or arc details. If the user requires another iteration to be studied, click on the **Save and Edit New Iteration** button in Figure 8-72 and/or Figure 8-73. This will display the output file for the iteration selected. If the LP Solver has created an infeasible solution, the output file will be similar to Figure 8-74, showing the message “INFEASIBLE LP SOLUTION. NSTOP = 16”. If it has created a feasible solution, then the output file will be similar to Figure 8-76, showing “LP SOLUTION OK. NSTOP = 17”. Once the user has viewed the output file (which is optional), Figure 8-77 is displayed for the user to select the next iteration for analysis.

8.9.3 USE OF LP SOLVER WITH USER-PREPARED INPUT FILES

The user may want to analyse a part of a network to investigate the flows in carriers under various capacities and penalties. In this case, LP Solver can be used to analyse this network, provided that the user prepares the input file relevant to the network in the required format by LP Solver. This format is similar to that for LP dump files (Figure 8-69 and Figure 8-70), with a particular format for arc details (i.e. Arc Name, From node, To node, Arc Cost and Arc Capacity) and node details (i.e. Node Name and Node Requirement). To assist the user to prepare the input file describing the network, a file called ‘*Template.lps*’ is given in the *c:\Realm\WorkedExamples* directory. **The user is advised to retain this file in *c:\Realm\WorkedExamples* directory without making any changes, for later use.** Copy this file into the Project directory and overwrite arc/node information as required to define the network. In addition, the user can add extra rows for arcs/nodes to define the network. The ‘*Template.lps*’ file is shown in Figure 8-78.

The operations for using LP Solver are similar to Sections 8.9.1 or 8.9.2.

```

Iteration No = 1
Seas = 1 Year = 1996 Repl = 1

Arc Details

 1 Arc Name-----| 001 002 000000001 99999999 00000000 1
 2 Arc Name-----| 001 002 000000001 99999999 00000000 2
 3 Arc Name-----| 001 002 000000001 99999999 00000000 3
 4 Arc Name-----| 001 002 000000001 99999999 00000000 4
 5 Arc Name-----| 001 002 000000001 99999999 00000000 5
 6 Arc Name-----| 001 002 000000001 99999999 00000000 6
 7 Arc Name-----| 001 002 000000001 99999999 00000000 7
 8 Arc Name-----| 001 002 000000001 99999999 00000000 8
 9 Arc Name-----| 001 002 000000001 99999999 00000000 9
10 Arc Name-----| 001 002 000000001 99999999 00000000 10
11 Arc Name-----| 001 002 000000001 99999999 00000000 11
12 Arc Name-----| 001 002 000000001 09999999 10000000 12

Node Details

 1 Node Name-----| 000000001 1
 2 Node Name-----| 000000001 2
 3 Node Name-----| 000000001 3
 4 Node Name-----| 000000001 4
 5 Node Name-----| 000000001 5
 6 Node Name-----| 000000001 6
 7 Node Name-----| 000000001 7
 8 Node Name-----| 000000001 8
    
```

Figure 8-78 Template.lps File

8.10 LP EXTRACT

LP Extract takes from the LP dump file the capacities and flows in the specified arc(s) for each iteration, and writes them to a new output file. By examining an LP Extract output file, the user can easily see how a problem carrier is behaving from iteration to iteration.

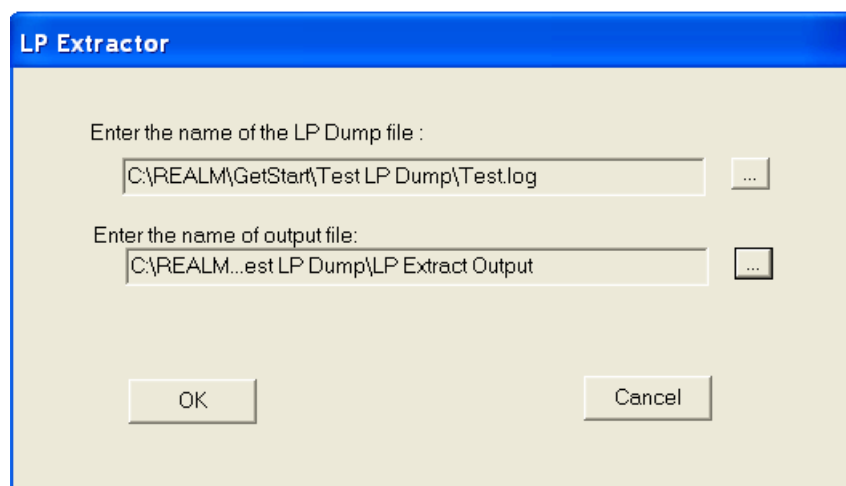


Figure 8-79 LP Extract Window

Click **OK** in the “LP Extractor” window (Figure 8-79) to display the “LP Extractor - Select Arcs” dialog box (Figure 8-80). By ticking the ‘Select’ check box next to each relevant arc, the user can specify which arcs to investigate (in terms of flow and

capacity) on an iteration-by-iteration basis. In Figure 8-80, only one arc has been selected, although several arcs can be selected for investigation in one LP Extract run. Click **OK** to Figure 8-80, which allows the user to view the output file. The output file corresponding to the selection in Figure 8-80 is shown in Figure 8-81. Note that the input file used in this case was the LP dump file shown in Figure 8-69 and the number of iterations in this dump file was 5. Within 5 iterations, flow in this carrier has not converged to a single value, but it was within the tolerance specified in Figure 8-69.

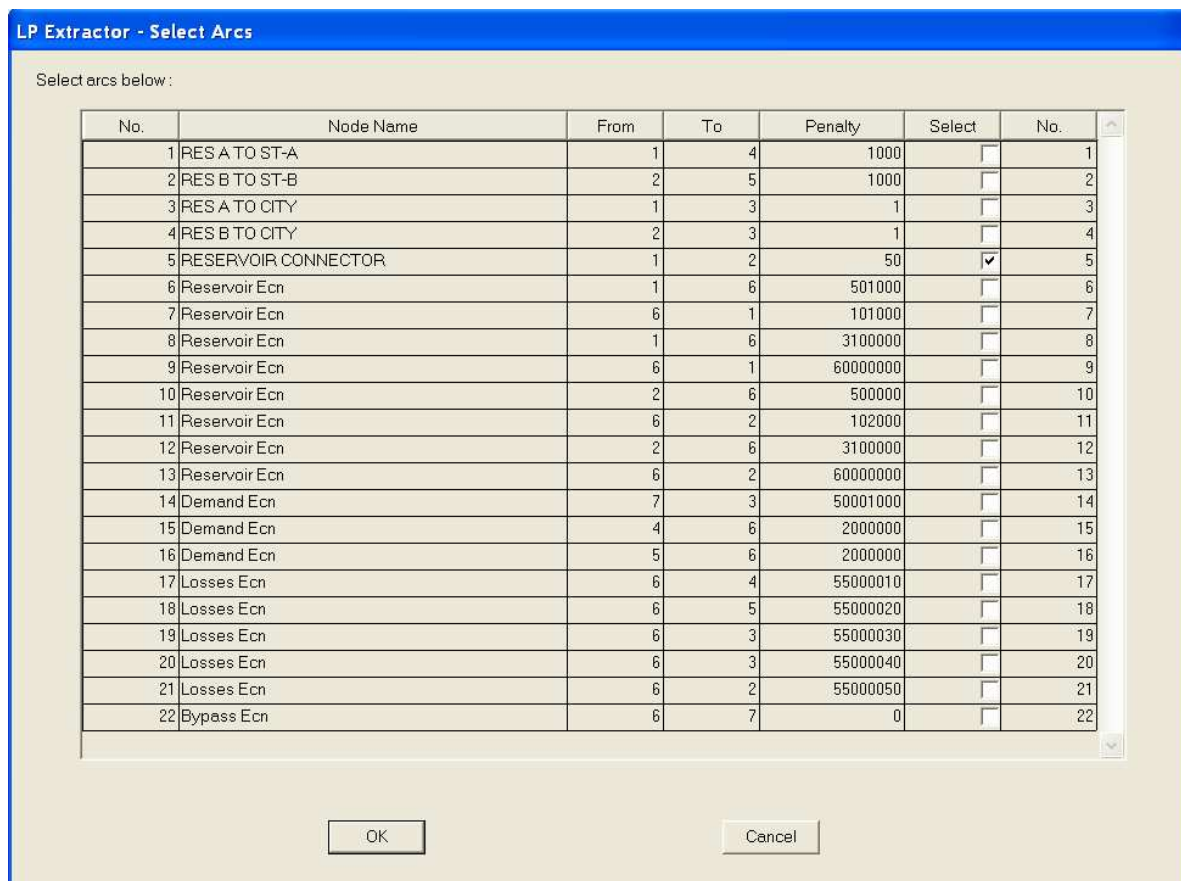


Figure 8-80 LP Extract – Select Arcs Window

```

lpextr
Multi-iteration LP dump extract
Flows and capacities

( 3f12.2          )
 3
ITERATION
RESERVOIR CONNE CAPC
RESERVOIR CONNE FLOW
    1.00    100.00    100.00
    2.00    6078.00    6078.00
    3.00    6078.00    5940.00
    4.00    6078.00    5151.00
    5.00    6078.00    5081.00
    
```

Figure 8-81 Output File from LP Extract

8.11 STREAMFLOW TRANSFORMATION

The Streamflow Transformation utility allows the user to alter input flows, such that streamflow properties that occur in one period of the flow record are replicated throughout the entire flow record. Similarly, climatic variables (rainfall, evaporation) can be altered.

The utility was developed to evaluate the effect of climate change on water resources modelling. To use the tool effectively in this context, the user must assume “climate step-change”. That is, the user must select a date such that all flows preceding that date are assumed to be “pre” climate change, and all flows after the date are assumed to be influenced by climate change. This date is referred to as the “Break Point Date”. Note that this utility does not allow representation of climate change as a trend – only as a “step-change”. Once the “before and after” periods are defined, the utility will then alter the “before” flows such that their properties match the properties of the “after” flows. This is done in one of two ways:

- Matching of seasonal averages: the user defines a seasonal regime (up to 12 “seasons”) and the utility adjusts “before” flow values such that, for each season, the average seasonal flow before the Break Point Date matches the average seasonal flow after the Break Point Date;
- Matching of flow duration curves (FDCs): the “before” flows are adjusted such that the FDC for “before” flows matches the FDC for “after” flows. This transformation relies upon splitting the FDCs into segments (e.g. deciles or percentiles – the user can decide) and comparing flow averages, segment by segment.

To transform streamflows (or climatic data):

Select the *Utilities::Streamflow Transformation* menu item. This displays the “Streamflow Transformation – Enter input file” dialog box (Figure 8-82).

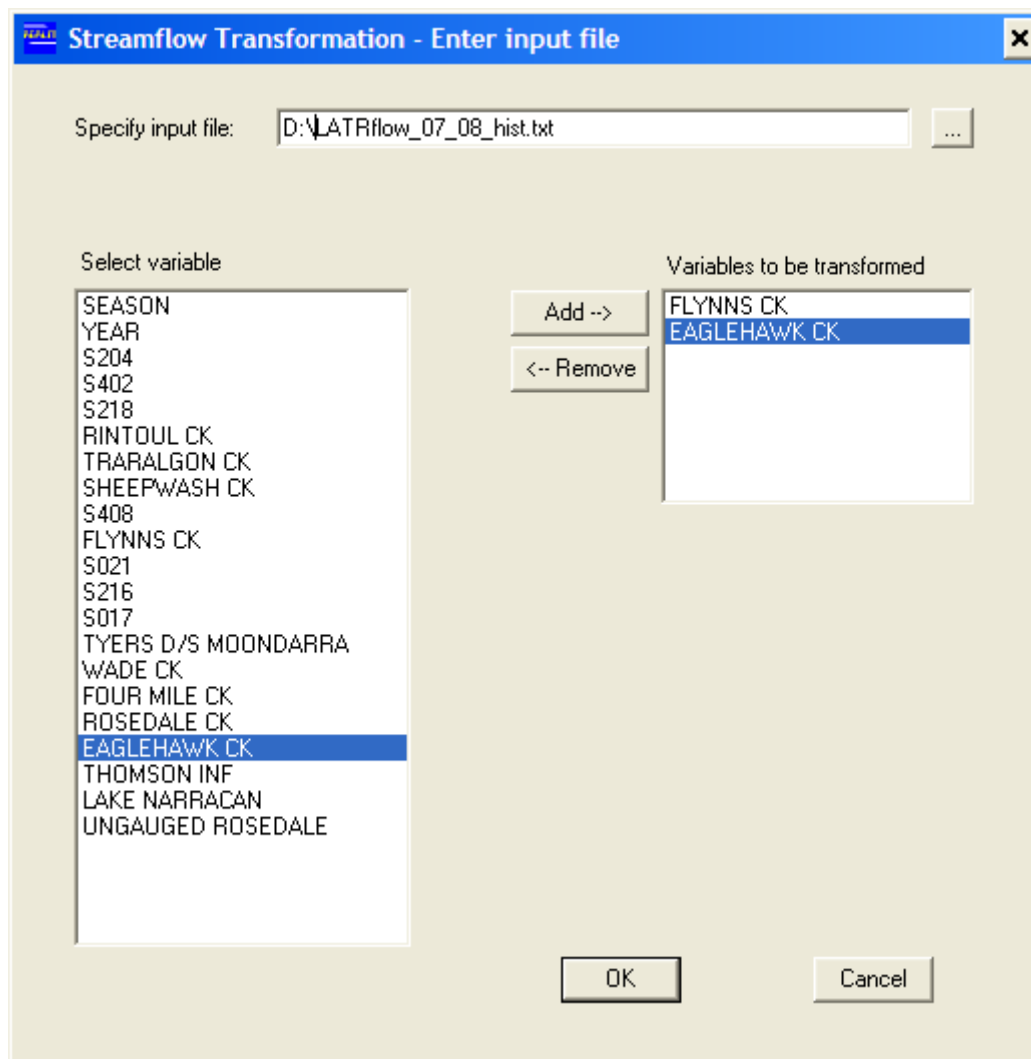


Figure 8-82 Streamflow Transformation – Enter Input File Dialog Box

Use the standard browse function to enter the directory for the relevant streamflow (or climatic variables) file in the 'Specify input file' field. Once the relevant streamflow file is opened, the variables will appear in the 'Select variable' field.

Use the **Add →** button to populate the 'Variables to be transformed' field with up to 8 variables. Hitting the **OK** button displays the "Streamflow Transformation – Enter Break Point Date" dialog box (Figure 8-83). Note that the start and end date for the file are shown to assist with selecting an appropriate Break Point Date. In Figure 8-83, the input data file starts at January 1957 and runs to June 2007.

Figure 8-83 Streamflow Transformation – Enter Break Point Date Dialog Box

The radio buttons give the user two options for specifying the Period A (“before” step change) and Period B (“after” step change):

- ‘Apply a Break Point Date (standard method)’: A Break Point Date is specified such that Period A (“before” step change) and Period B (“after” step change) are contiguous and together run for the full period of the input data file.
- ‘Use customised settings’: Under this option the user enters the start date and the end date for Period A (“before” step change) and for Period B (“after” step change) respectively. Because Period A and Period B are simply two discrete time periods, there is no requirement for the periods to be contiguous or to run for the full period of the input data file. (Note however, that Period A always precedes Period B.)

When the **Break Point Date Help** button is hit Figure 8-84 is displayed.

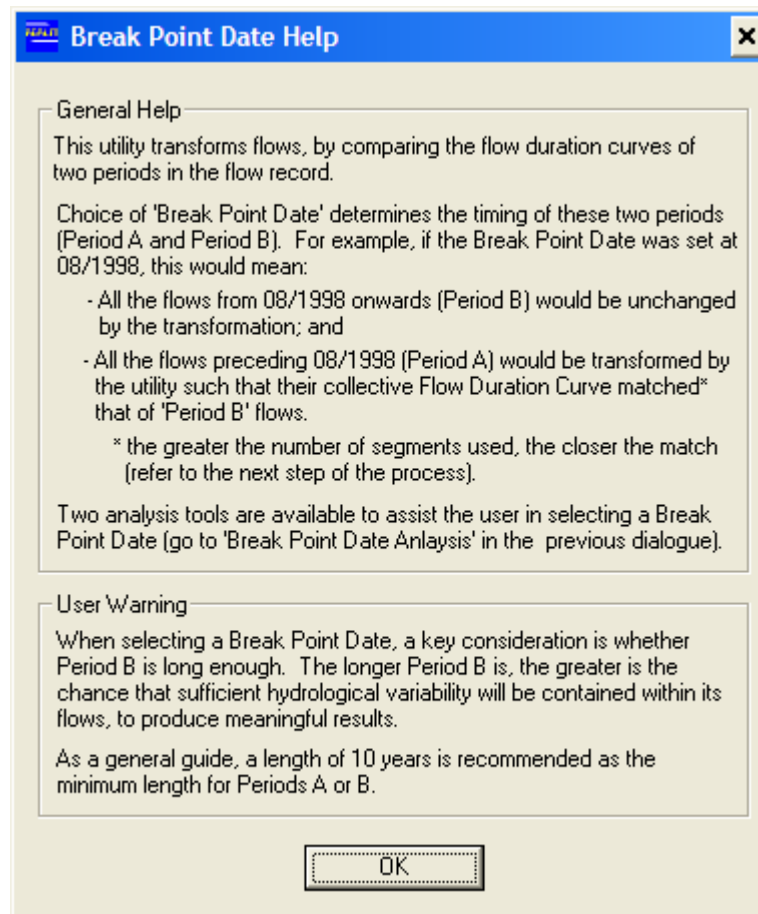


Figure 8-84 Break Point Date Help Text Box

8.11.1 BREAK POINT DATE ANALYSIS

Any date within the period of the input file may be entered as the Break Point Date. REALM offers two analyses to assist the user to select an appropriate Break Point Date:

- Single Mass Curve Analysis
- Ratio of Averages Analysis.

(Nevertheless, selection of an appropriate Break Point Date can be a complex and subjective task, and may require additional statistical analysis beyond what is provided by the utility.)

In the “Streamflow Transformation – Enter Break Point Date” dialog box (Figure 8-83), click the **Break Point Date Analysis** button to display the text in Figure 8-85.

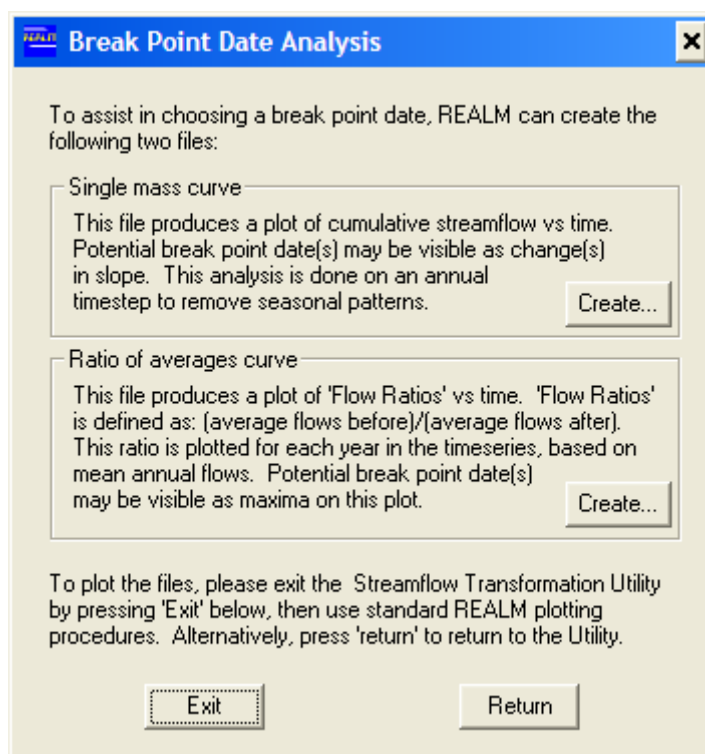


Figure 8-85 Break Point Date Analysis Text Box

8.11.1.1 SINGLE MASS CURVE ANALYSIS

This common analysis involves plotting cumulative streamflow versus time. The vertical axis of a single mass curve measures volume (eg. ML) and the line itself represents the integration (“area under the curve”) of the flow series. Example curves are given in Figure 8-86.

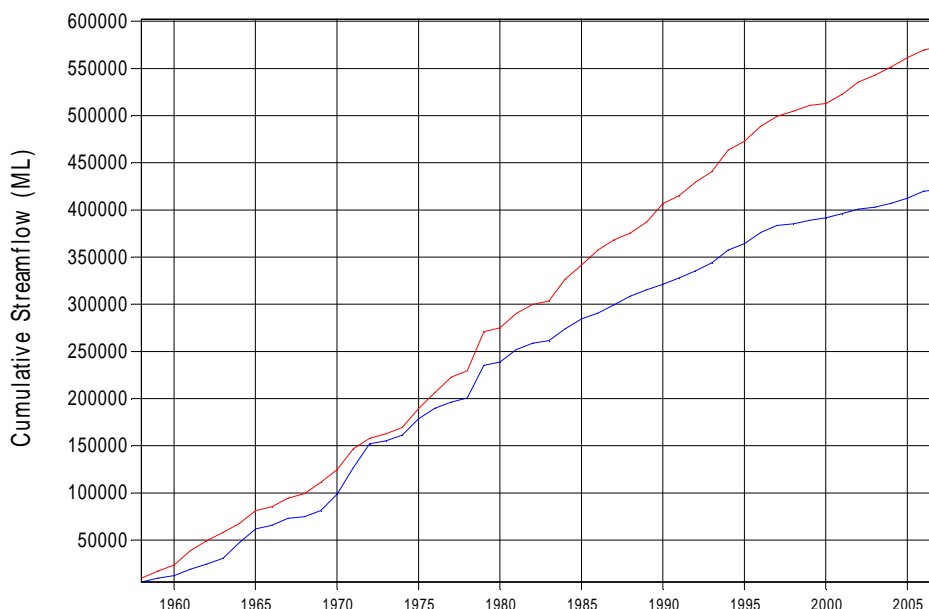


Figure 8-86 Plot of a Single Mass Curve File for Flynn's Creek (red) and Eaglehawk Creek (blue) in the Latrobe Catchment.

The gradient of a single mass curve over a certain period is related to how wet or dry that period of time is. Steeper gradients indicate that flow was accumulating more quickly, meaning greater flow rates. Streamflow tends to vary according to the annual seasonal cycle; therefore, plotting single mass curves on a daily or monthly time-step tends to result in a jagged-edge, “saw-tooth” line. For this reason, the Streamflow Transformation utility creates all Single Mass Curve files (...SMC.fan) on an annual time-step for the calendar year (January to December).

From Figure 8-86, it can be seen that the gradients of the single mass curves fluctuate with wet and dry periods (typically lasting a few years). However, the long-term average gradient, over 10 years or more, remains reasonably constant during the 60s, 70s and 80s. The more steady the gradient over a period, the less appropriate it is to place a Break Point Date within that period. The most appropriate point to put a Break Point Date is where there is a visible, long-term change in gradient. In Figure 8-86, there is a period of around 10 years at the end of the flow record which appears to have a different (lower) gradient than the preceding years. Therefore, in this case, the most appropriate place for a Break Point Date would be at the beginning of this later period (around 1997/98).

By default, the plot of Single Mass Curves produced by the utility: (1) contains only the series selected by the user for transformation; and (2) begins at the start year of the file. At times it may be useful to have the curves start at a different (later) date, and this can be achieved by loading a shortened REALM format file containing only the period that the user wishes to plot.

To perform Single Mass Curve Analysis:

Hit the **Create** button next to “Single mass curve” on the “Break Point Date Analysis” dialog box.

A “File Creation Successful” message will appear, directing the user where to access the newly created ...SMC.fan file.

Exit the Streamflow Transformation utility.

In the Plot utility, use the time series plot function (Section 8.1.3) to generate a Single Mass Curve from the ...SMC.fan file.

Choose a Break Point Date from the Single Mass Curve.

Navigate back to the “Streamflow Transformation – Enter Break Point Date” dialog box and enter the chosen Break Point Date.

8.11.1.2 RATIO OF AVERAGES ANALYSIS

This analysis assumes that the aim when choosing a Break Point Date is to choose a date that maximises the differences in flow properties between Period A and Period B. The Ratio of Averages analysis focuses on only one flow property: average flow. For each date in the flow series, the utility calculates the average flow for the preceding period and the average flow for the following period. This information is written to a file (...ROA.fan) that can be plotted in REALM (an example is given in Figure 8-87). The user can then manually inspect the dates under consideration as the Break Point Date, to see how much greater the average flows before the date (Period A) are compared with the average flows after the date (Period B). As for the single mass curves, the streamflow transformation utility calculates the ratios on an

annual basis, for calendar years (January to December).

If the aim is to pick the date that provides maximum contrast between before-and-after, then the user should pick the date corresponding to the maximum of the Ratio of Averages plot. For example, in Figure 8-87 the most appropriate Break Point Date for this series is in 1998.

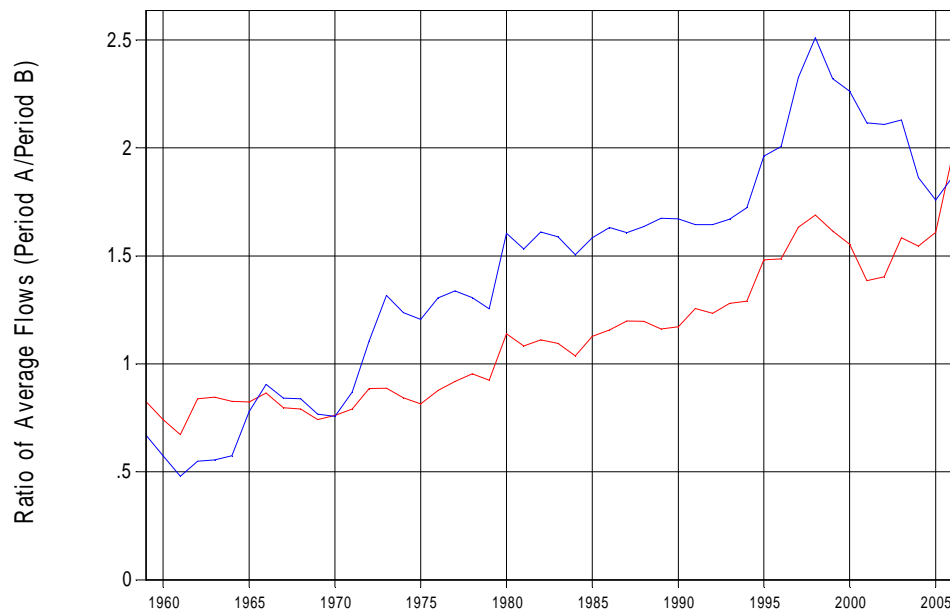


Figure 8-87 Plot of a Ratio of Averages File for Flynn's Creek (red) and Eaglehawk Creek (blue) in the Latrobe Catchment.

The Ratio of Averages analysis has limitations, as follows:

- The periods at the very start and the very end of the file do not provide reliable Ratio of Averages values. This is because the stability of the ROA values decreases as the number of values in either Period A or Period B declines. Although the final few years may contain the highest value of ROA, this value will be based on a very short period and, as such, is very sensitive to an update of data (say, when an extra year is added in a routine REALM update).
- The assumption that climate change can be characterised by a single "step" change is a crude simplification. If the observed changes in flows are better characterised as a gradual change rather than a single step, this may lead to a Ratio of Averages value that continually increases with time, rather than coming to a global maximum. An example of this is shown in Figure 8-88. This can increase the difficulty of choosing a break point, and in many cases, no appropriate break point date may be evident.

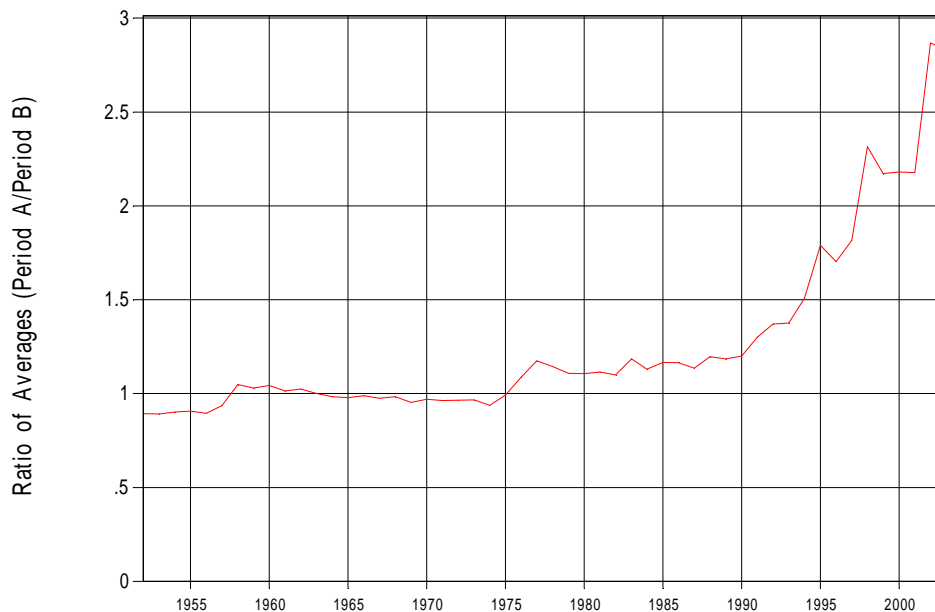


Figure 8-88 Plot of a Ratio of Averages File for Hollands Creek in the Broken River Catchment. In this case, the successively higher peaks in ROA value make it difficult to choose a breakpoint using this method.

To perform Ratio of Averages Analysis:

Hit the **Create** button next to “Ratio of averages curve” on the “Break Point Date Analysis” dialog box.

A “File Creation Successful” message will appear, directing the user where to access the newly created ...ROA.fan file.

Exit the Streamflow Transformation utility.

In the Plot utility, use the time series plot function to generate a Ratio of Averages curve from the ...ROA.fan file.

Choose a Break Point Date from the Ratio of Averages curve.

Navigate back to the “Streamflow Transformation – Enter Break Point Date” dialog box and enter the chosen Break Point Date.

8.11.2 DEFINING PERIODS A & B

To apply a Break Point Date (Standard Method):

Select the ‘Apply a Brake Point Date (standard method)’ radio button and populate the ‘Month’, ‘Year’ and ‘Day’ (if appropriate) fields of “Break Point Date” with the date that is considered to correspond to a step-change in climatic conditions. In Figure 8-83, January (the 1st month) of 1998 has been selected as the Break Point Date.

Note the a warning that Period B may be too short will appear if the Break Point Date selected results in a Period B of less than 10 years. However, no warning will appear if Period A is less than 10 years. The user needs to take care to ensure that Period A is of adequate length.

Hit the **OK** button. The “Please select Transformation Type” dialog box will appear. This is explained in Section 8.11.3

To use Customised Settings:

In the “Streamflow Transformation – Enter Break Point Date” dialog box (Figure 8-83), select the ‘Use customised settings’ radio button. Click the **About customised settings** button to display the text in Figure 8-89.

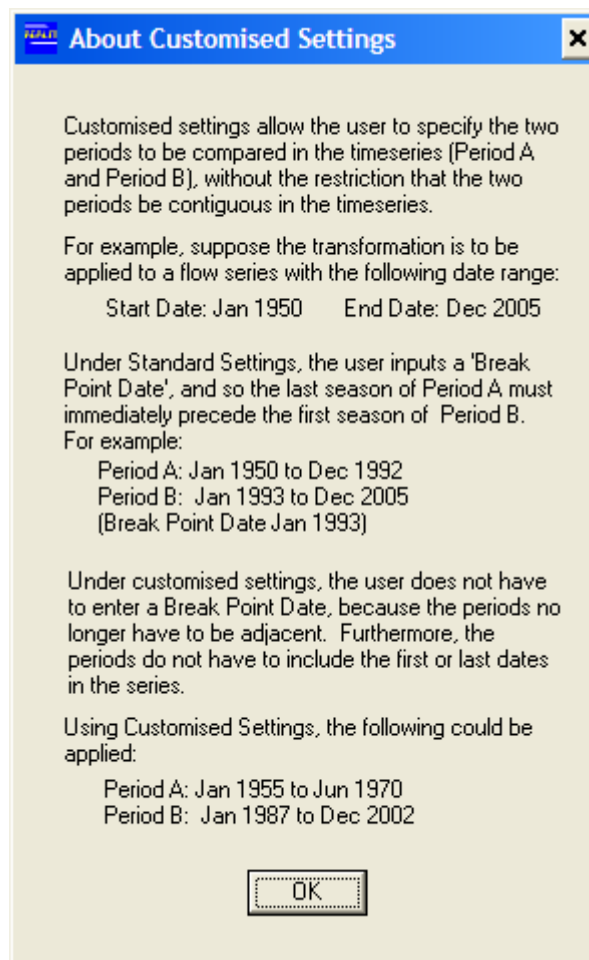


Figure 8-89 About Customised Settings Text Box

Click the **OK** button to return to the “Streamflow Transformation – Enter Break Point Date” dialog box.

Click the **Go to customised settings** button to display the “Customised Settings” dialog box (Figure 8-90). Populate the ‘Start Date’ and ‘End Date’ fields for Period A and Period B.

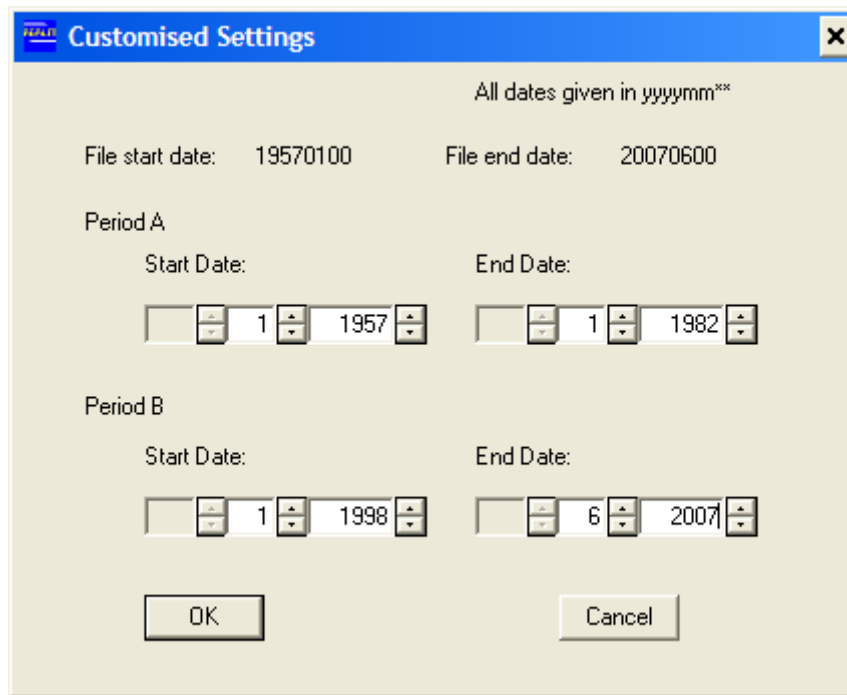


Figure 8-90 Customised Settings Dialog Box

Hit the **OK** button. The “Please select Transformation Type” dialog box will appear.

8.11.3 TRANSFORMATION TYPES

REALM offers two methods for transforming streamflows in Period A (“before” climate step-change) such that their properties match the properties of the Period B streamflows (“after” climate step-change):

- Transformation by seasonal factors
- Transformation by comparison of Flow Duration Curves (FDCs).

Transformation by Seasonal Factors

In this method, the utility adjusts the “before” flow values such that, for each season, the average seasonal flow before the Break Point Date matches the average seasonal flow after the Break Point Date.

The user defines the seasonal regime to be used in the transformation. As this definition is on a monthly basis, the maximum number of seasons is 12. Once the seasons are defined, the following steps are followed to complete the transformation:

1. For Period A, all the flows belonging to the first season are grouped, and an average flow is found for that season under Period A. This is done for all seasons that the user has defined.
2. The above step is repeated for Period B.
3. The ratio of the Period B average to the Period A average is found for each season.

4. For each flow value in Period A, a transformed flow is derived by multiplying by the factor that is applicable for that season.

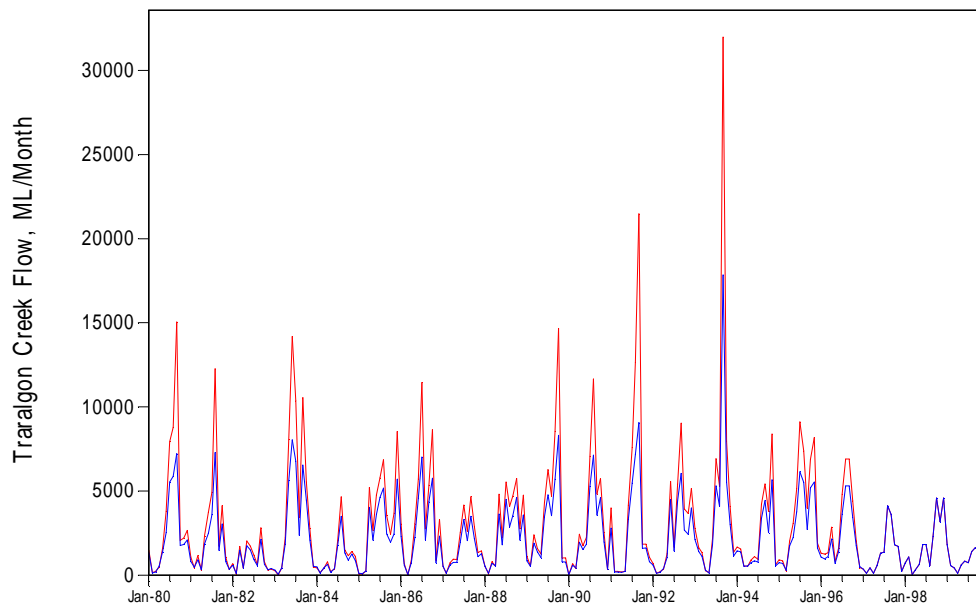


Figure 8-91 Original (red) and transformed flows (blue) for Traralgon Creek during the 1990s, subject to the seasonal transformation described in Figure, with a January 1997 breakpoint (this a portion of the series 1957 – 2006).

Although the user may specify up to 12 “seasons” (corresponding to the 12 months), each single “season” in Period A corresponds to a single “season” in Period B. This means that, for each “season”, flow in Period A is transformed by the ratio of mean flow across all of Period B to mean flow across all of Period A. This is consistent with the methodology that has been commonly used in the past to transform streamflow data across a break point. A disadvantage of this method is the risk that already severe single-year droughts in Period A (such as in 1982/1983) may be made more severe by factoring down using a single conversion factor.

To specify transformation by Seasonal Factors:

Select the ‘Transformation by seasonal factors’ radio button on the “Please select Transformation Type” dialog box. Clicking the **OK** button displays the “Define Seasons” dialog box (Figure 8-92).

Specify the seasonal regime by selecting the appropriate radio button on the “Define Seasons” dialog box.



The dialog box is titled "Define Seasons" and contains the following elements:

- Text: "Please specify seasonal regime:"
- Radio buttons for "One season", "Two Seasons" (selected), "4 Seasons", "12 Seasons", and "Other (please specify)".
- A "Season Definition..." section containing a table of months and their assigned season numbers.
- Buttons for "OK" and "Cancel".

Season Definition...			
January	1	July	2
February	1	August	2
March	1	September	2
April	1	October	2
May	1	November	2
June	2	December	1

Figure 8-92 Define Seasons Dialog Box

Note that the when a seasonal regime has been specified, the fields in the "Seasons Definition" block show into which seasonal group each month falls. In Figure 8-92, 'Two Seasons' has been selected. The months December to May inclusive fall into season 1, and the months June to November inclusive fall into season 2. If the 'Other (please specify)' radio button is selected, the fields next to the months in the "Season Definition" block are activated, allowing the user to group the months into user-defined "seasons".

Hitting the **OK** button generates a "Summary of Inputs and User Warning" box (Figure 8-93). Note that the location and name of the output file can be changed from the default by using the browse button.

Summary of Inputs and User Warning

Specify name for output REALM file:
 ...

File to be transformed:

Series to be transformed:

Number of Seasons and "Seasons Code":

Period A (to be transformed)
 Start Date: End Date: # of flow values:

Period B
 Start Date: End Date: # of flow values:

(All Dates given in yyyyymm***)

PLEASE NOTE that this transformation method is intended for use in the field of water resource modelling. Use in other types of hydrological studies, such as Flood Frequency Analysis and Environmental Flow studies, may be inappropriate.
 The quality of the transformed results for Period A is very highly dependant on the length and quality of the flows for Period B.
 The shorter the length of Period B in this technique, the less reliable the results of the transformation will be, particularly for very high or very low flows.
 This is because longer periods of record are more likely to capture the long-term hydrological variability in a system.
 If the transformed flows from this technique are used in studies in, for example, Environmental Flow Studies or Flood Hydrology Studies, it is important to note the following:
 the results obtained will be of similar quality to those obtained using only the Period B flows.
 Therefore, it is not recommend to use this transformation for such studies.
 Users of this transformation technique should have a good understanding of the theory and assumptions employed.

Figure 8-93 Summary of Inputs and User Warning Box

Transformation by comparison of Flow Duration Curves

The transformation by comparison of Flow Duration Curves (FDCs) method adjusts the “before” flows such that the FDC for “before” flows matches the FDC for “after” flows. The following steps are followed to complete the transformation:

1. The streamflow data are ranked from lowest to highest, separately for Period A and for Period B.
2. The ranked data are split into segments (eg. deciles or percentiles), referred to as “bins”.
3. The average flow is then calculated for each bin for Period A and (separately) for Period B.

4. A conversion factor (i.e. the ratio of average flow in Period B to average flow in Period A) is calculated for each bin.
5. For each flow value in Period A, a transformed flow is derived by multiplying by the conversion factor that is applicable to that bin.

For very low flows, the adjusted flows produced using the discretised FDC method typically are higher than those produced using the transformation by seasonal factors. The FDC method generally produces transformed flow data that better match the distribution of the historical data.

The more segments (**referred to in REALM as “bins”**) the FDCs are split into, the more precisely the shape of the FDC for the transformed Period A data matches the shape of the FDC for Period B. However, the more segments Period B flow data are split into, the less data points per segment, and therefore, the greater the risk that the (smaller) sample size is unrepresentative of the hydrological conditions. The number of data points in Period B (or Period A – whichever is the lesser) is the upper limit for the number of segments.

Where the number of data points in a period (Period A or Period B) is not exactly divisible by the number of bins specified, some data points will be shared between bins. These data points are referred to as “partials”. For example, if there were 492 streamflow data in Period A and 10 bins specified, each bin would contain 49.2 data points. The streamflow data are ranked from lowest to highest and the 50th data point is split between bin 1 and bin 2, the 99th data point is split between bin 2 and bin 3 etc. “Partials” are transformed by multiplying by a weighted average of the conversion factors for the two bins that the data point is shared between. This can be seen in the last line of Figure 8-98, which shows the details of the transformation of a “partial” data point, split 20% into bin 1 and 80% into bin 2. For all the other data points in the file, the bin number is an integer from 1 to 10 [although zeros are shown to two decimal places], indicating that that data point is wholly in a single bin. The value 1.80 is shown for the bin number for the last data point, indicating that it is shared between bin 1 and bin 2. Similarly, the conversion factor is 0.86, which has been derived thus:

CONVERSION FACTOR for bin 1 = 1.05

CONVERSION FACTOR for bin 2 = 0.81 [Not shown in example file]

CONVERSION FACTOR for partial = (20% × 1.05) + (80% × 0.81) = 0.86

Sinclair Knight Merz (2008) “Streamflow Transformation for Climate Change: User Guide” examines in detail how different streamflow transformations perform, and may be downloaded by following the instructions under Section 1.5.3.

To specify transformation by comparison of FDCs:

Select the ‘*Transformation by comparison of Flow Duration Curves*’ radio button on the “Please select Transformation Type” dialog box. Clicking the **OK** button displays the “Streamflow Transformation – Enter number of segments” dialog box (Figure 8-94).

Enter the number of segments in the ‘*Specify number of segments*’ field. Hit the **OK** button.

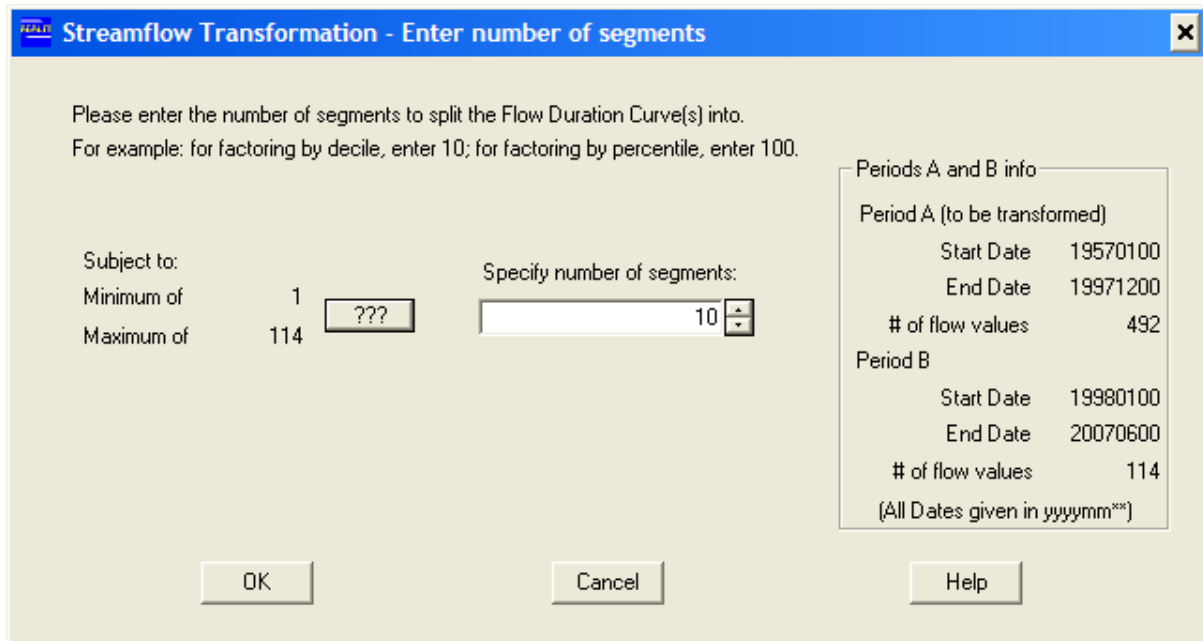


Figure 8-94 Streamflow Transformation – Enter Number of Segments Dialog Box

Note that hitting the button displays the text box in Figure 8-95.

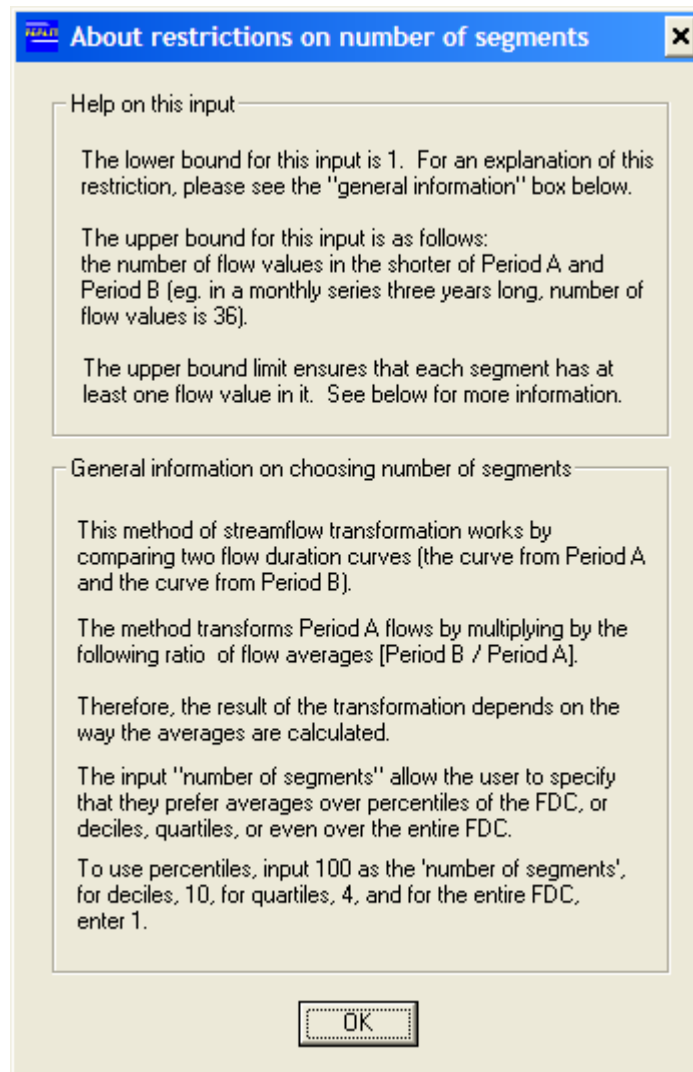


Figure 8-95 About Restrictions on Number of Segments Box

Hitting the **OK** button generates a "Summary of Inputs and User Warning" box (Figure 8-93).

8.11.4 OUTPUT OPTIONS

Hit the **Output Options** button on the "Summary of Inputs and User Warning" box to display the "Output Options" dialog box (Figure 8-96).

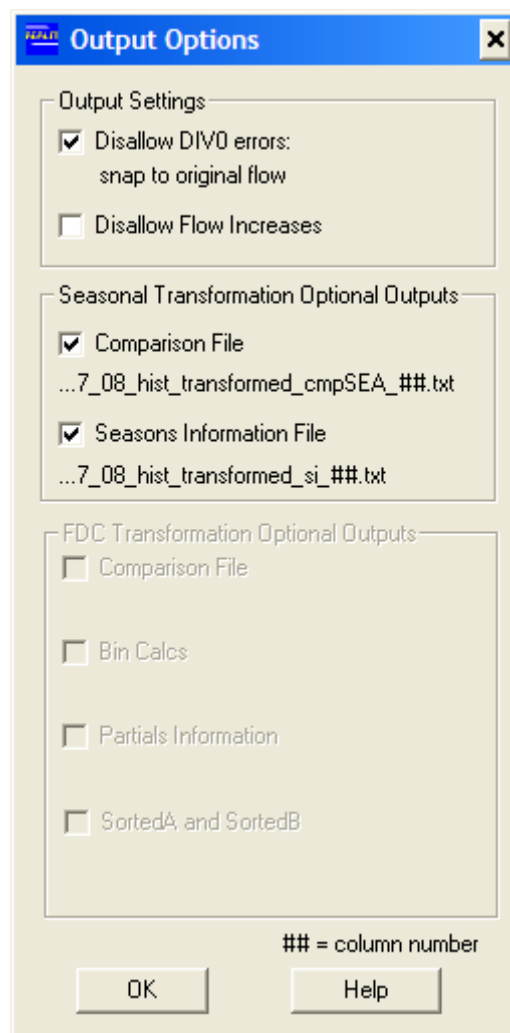


Figure 8-96 Output Options Dialog Box

The selections in the “Output Options” dialog box are as follows:

Output Settings:

Disallow DIV0 errors: snap to original flow: (This check box is ticked as a default setting). Ticking this check box ensures that when the ratio of inflows for Period B to Period A is calculated, if the flows in Period A for that “season” are zero, then the original flow value is written to the output file. This avoids errors that would otherwise be caused by having a zero dominator.

Disallow Flow Increases: Ticking this check box writes the original (i.e. untransformed) flow to the output file for data points in any season/bin where flows in Period B are greater than in Period A.

Seasonal Transformation Optional Outputs

These output options are active when the user has selected ‘Transformation by seasonal factors’ in the “Please select Transformation Type” dialog box.

Comparison File: Tick this check box to generate a separate Comparison File for each variable that has undergone streamflow transformation. Part of an example Comparison File is shown in Figure 8-97. Note that the original flow and transformed flow are given, enabling the user to easily plot timeseries of both on the

same axes for comparison. The naming convention for Comparison Files generated by seasonal transformation is *[name of input file]_transformed_cmpSEA_[column number of relevant variable in the input file].txt*.

```
#####2
Original and Transformed flow series. This file relates only to column 10 (FLYNNS CK)
Created for REALM by utility 'Streamflow Transformation'.
Based on original file:D:\Workstation Configuration\Documents and
Settings\ab82\Desktop\LATRflow_07_08_hist.fmn
'Transformed flows' based on the following: Period A: 19570100 to 19971200, Period B:
19980100 to 20070600 . Number of Seasons: 2
(2I12, A12, f12.0, 2f12.2, f12.0)
7
SEASON
YEAR
PERIOD
ORIGINAL FLOW
SEASON (USER DEFINED)
CONVERSION FACTOR
TRANSFORMED FLOWS
      1      1957      A      55.      1.      0.41      23.
      2      1957      A      9.      1.      0.41      4.
      3      1957      A      81.     1.      0.41      33.
      4      1957      A      52.     1.      0.41      21.
      5      1957      A      288.    1.      0.41      119.
      6      1957      A      617.    2.      0.80      493.
      7      1957      A      1913.   2.      0.80      1527.
```

Figure 8-97 Part of a Comparison File generated by seasonal transformation

Seasons Information File: Tick this check box to create a separate Seasons Information File for each variable that has been transformed. In Figure 8-82, two streamflow variables were selected for transformation (i.e. "FLYNNS CK" and "EAGLEHAWK CK"), so there will be two Seasons Information Files created, each with the name *[name of input file]_transformed_si_[column number of relevant variable in the input file].txt*. This file contains the statistics calculated for the transformation, including the sum of flows, the number of flow values and the average flow for each season in each period. The ratio of average flow in Period B to Period A (i.e.the conversion factor used to transform the Period A flows) is also included.

```

####2
Original and Transformed flow series. This file relates only to column 10 (FLYNNS CK)
Created for REALM by utility 'Streamflow Transformation'.
Based on original file:D:\Workstation Configuration\Documents and
Settings\ab82\Desktop\LATRflow_07_08_hist.fmn
'Transformed flows' based on the following: Period A: 19570100 to 19971200, Period B:
19980100 to 20070600 Number of Segments: 10
(2I12, A12, f12.0, 2f12.2, f12.0)
7
SEASON
YEAR
PERIOD
ORIGINAL FLOW
BIN
CONVERSION FACTOR
TRANSFORMED FLOWS

```

1	1957	A	55.	3.00	0.72	40.
2	1957	A	9.	1.00	1.05	9.
3	1957	A	81.	3.00	0.72	58.
4	1957	A	52.	3.00	0.72	38.
5	1957	A	288.	5.00	0.84	242.
6	1957	A	617.	7.00	0.71	435.
7	1957	A	1913.	9.00	0.70	1340.
2	1960	A	16.	1.80	0.86	14.

Figure 8-98 Part of a Comparison File generated by FDC transformation

FDC Transformation Optional Outputs

These output options are active when the user has selected 'Transformation by comparison of Flow Duration Curves' in the "Please select Transformation Type" dialog box.

Comparison File: Tick this check box to generate a separate Comparison File for each variable that has undergone FDC transformation. This file is analogous to the Comparison File generated for each variable transformed by seasonal factors. Part of an example Comparison File is shown in Figure 8-98. Compare Figure 8-97 and Figure 8-98, which have been generated with identical input data but different transformation methods. Relative to the seasonal transformation method, the FDC comparison method has produced higher low flows (in Bins 1-5) but lower high flows (in Bins 6-10). The naming convention for Comparison Files generated by FDC comparison is *[name of input file]_transformed_cmpFDC_[column number of relevant variable in the input file].txt*.

Bin Calcs: Tick this check box to generate a separate Bin Calculations file for each variable that has undergone FDC transformation. The Bin Calculations file contains the summary information for each bin (i.e. number of bins that the input data are divided into, lower and upper percentile of input data in each bin, average flow in each bin in Period A and in Period B, conversion factor applied to flow data in each bin.) The naming convention for Bin Calculations files is *[name of input file]_transformed_bc_[column number of relevant variable in the input file].txt*.

Partials Information: Tick this check box to generate a file with all the information on "partials" (i.e. data points split between two bins). The "partials" file lists the lower and upper bounds for each bin in each of Period A and Period B, each data point shared between bins and how that data point has been split between bins. The naming convention for partials files is *[name of input file]_transformed_par_[column number of relevant variable in the input file].txt*.

SortedA and SortedB: Tick this check box to generate two separate sorted files for each variable that has undergone FDC transformation:

- A file listing all the data points in Period A ranked from lowest to highest. The naming convention for files showing the sorted data in Period A is *[name of input file]_transformed_stA_[column number of relevant variable in the input file].txt*.
- A file listing all the data points in Period B ranked from lowest to highest. The naming convention for files showing the sorted data in Period B is *[name of input file]_transformed_stB_[column number of relevant variable in the input file].txt*.

Each sorted file also lists which bin each data point has been sorted into, and identifies how many data points are in each bin. Each data point is identified as “full” (fully in one bin) or “partial” (shared between two bins).

8.11.5 RUN TRANSFORMATION

Hit the **Run Transformation** button to run the streamflow transformation and write the outputs to the specified files.

When the calculations are complete, the “Output Viewing” box is displayed. REALM produces 2 output files (in addition to the Optional Outputs specified in Section 8.11.4):

- *REALM Output File*: A streamflow file containing the transformed flows. **(Note that the transformed streamflows have the same variable names as the original streamflows).** The naming convention for the output file with the relevant variables transformed is *[name of input file]_transformed*.
- *Flow Duration Curve*: A file containing probability of exceedence values for:
 - the original streamflows during Period A [“PER A ORIGINAL”]
 - the (original) streamflows during Period B [“PER B ORIGINAL”]
 - the transformed streamflows during Period A [“PER A TRANSFORMED”].

(Note that “Year” and “Season” are dummy variables.)

The naming convention for the output file is *[name of input file]_transformed_FDC*.

For hints on plotting the outputs, click on the relevant **How to plot** button in the “Output Viewing” box.

Plotting the Flow Duration Curve file allows the user to examine how well the characteristics of the transformed Period A flows match those of Period B flows. For example, the FDCs shown in Figure 8-99 were generated using the ‘Transformation by seasonal factors’ method. The curves diverge at low inflows: for Period B there is no inflow about 20% of the time, whereas for the transformed Period A data, there is no inflow about 15% of the time. In this instance, the distribution of transformed Period

A inflows could be made to better match the distribution of Period B inflows by using the 'Transformation by comparison of Flow Duration Curves' method with an appropriate number of bins.

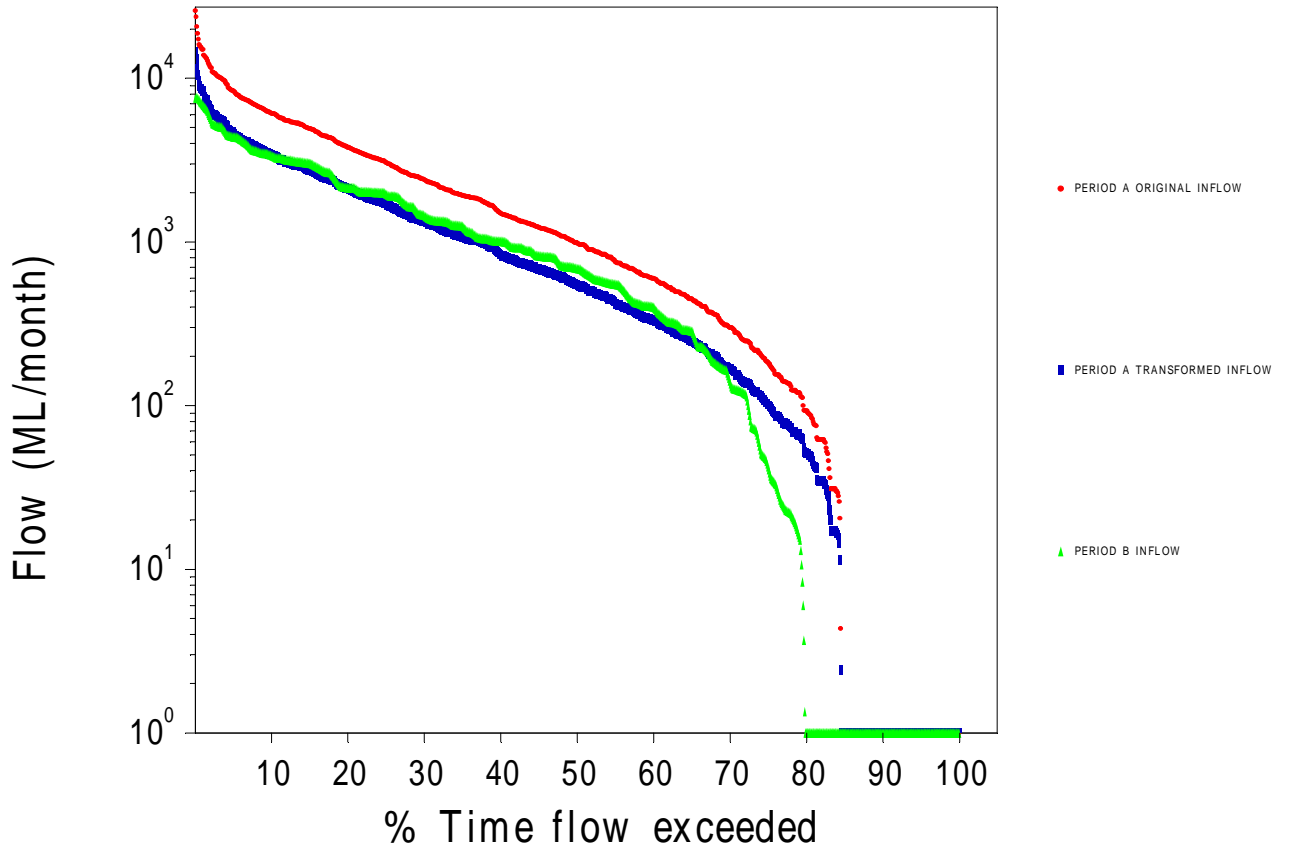


Figure 8-99 Flow Duration Curves for comparison of the distribution of original and transformed streamflows

8.12 DATABASE EXTRACTION

In most cases, the simulation results of large and complex systems (which require high computing time) are stored in a binary data base. This data base option was developed to eliminate the need to repeat several simulation runs with different output settings. With the data base option, all simulation results related to all output settings are stored in the data base. The required output files can then be extracted from the data base, whenever they are required. During REALM Setup, the user can specify that all output is to be sent to a data base (Section 6.6). Then during simulation, a data base file with its log filename and extension of *bdb* is created.

Select *Utilities::Data Base Extraction*, which displays a standard browsing window. Browse through the directories to select the required data base file for creating the required output files. Once the required data base file is selected, click the **Open** button. This displays the “Select data sets to be extracted” dialog box (Figure 8-100). This dialog box allows the user to select the required output files. This dialog box is similar to Figure 6-22 (Section 6.6).

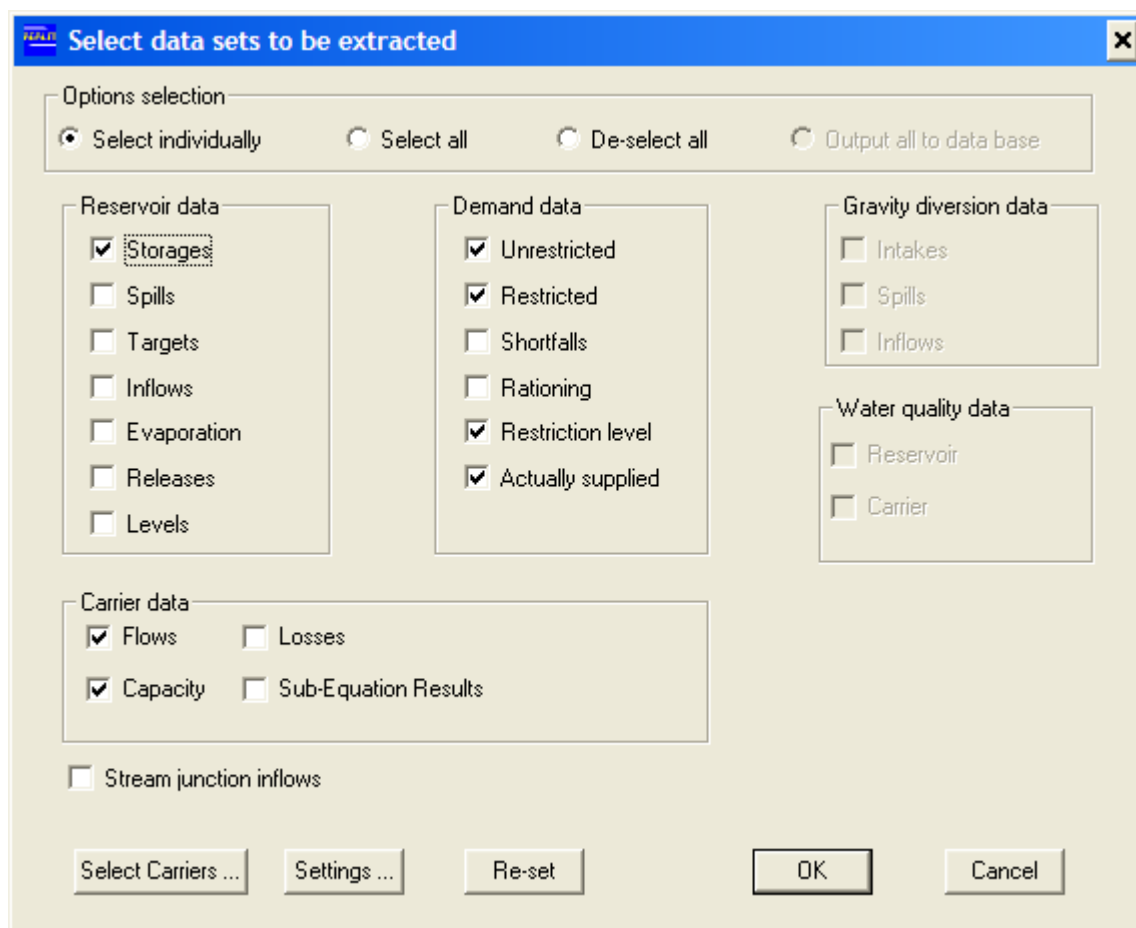


Figure 8-100 Select Data Sets to be Extracted Window

The output selections in Figure 8-100 can then be selected as in Section 6.5 to create various output files from the data base. If any output files related to carriers are selected, then it is also necessary to select carriers as in Section 6.5. The user can also load settings already saved in this directory, by clicking on the **Settings** button in Figure 8-100, which displays Figure 8-101. This window shows *testotpt.rlm* as the default settings file, which has several settings (e.g. Setting 3) already stored. Any of

these settings can be loaded to create the required output files from the data base. Or the user can browse through the directories to use other *xxxxotpt.rlm* (*xxxx* being first four letters of a log file) to select other (saved) output settings. **It is important that these *xxxxotpt.rlm* files are compatible with the system file(s) used in the data base file.**

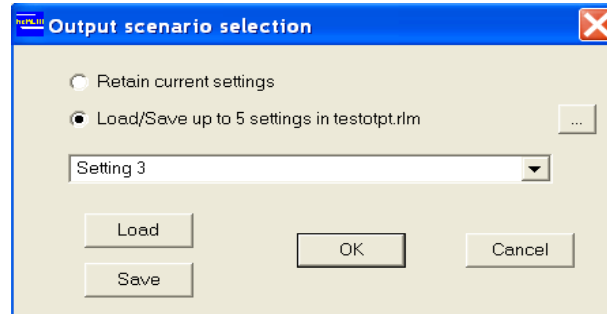


Figure 8-101 Output Scenario Selection for Data Base Extraction

The user is referred to Section 6.5 for details of selecting output settings. The format of the output files created from the data base extraction is exactly same as that of the output files created during a (normal) REALM simulation run with selected output settings. Therefore, the user is referred to Section 7.2.2 for details of these output files.

Chapter 9

9 REFERENCES

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