CALSIM

Water Resources Simulation Model

User's Guide

Draft Documentation

QuickStart Guide

The QuickStart guide in the following sections is a minimal user's guide designed to assist a new user in getting started with CALSIM. It presents the basic usage of the model through a sample water resources system. The sample study may be obtained from the CALSIM web page. The QuickStart guide is divided into three sections: (1) Assembling a Study, (2) Running a Study, and (3) Viewing Results.

Assembling a Study

In this section you will download the existing sample study, investigate the structure of the study, open a study, and view the system configuration.

Step 1: Download the Sample Study from the CALSIM web page

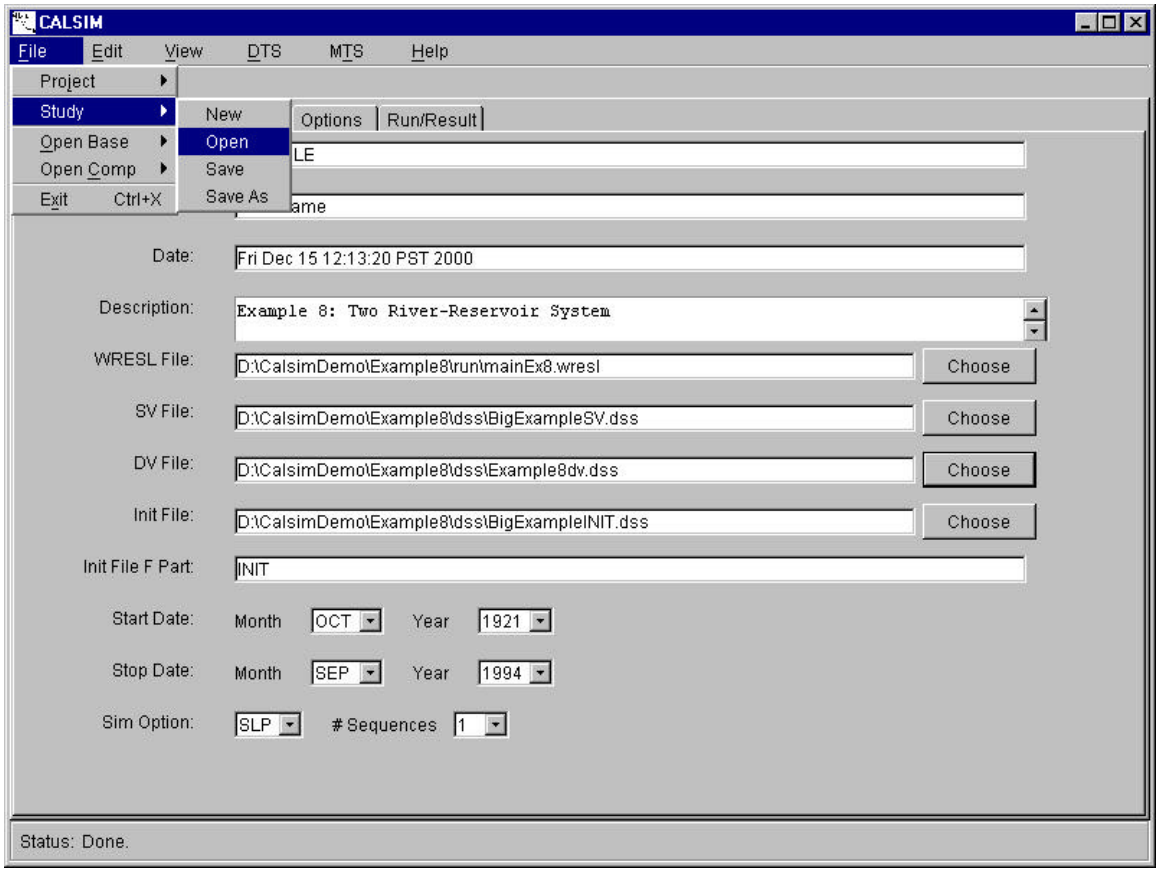
- On the CALSIM web page, click on the *Sample Study* link and save the zip file to a temporary directory on your machine (ie. c:\temp or d:\temp).
- Create a directory on your machine named "CalsimDemo" (i.e. d:\CalsimDemo). This will serve as the directory for all sample study files.
- Extract the files from the zipped file to the "CalsimDemo" directory. Be sure to keep the folder structure intact when extracting the files.
- If this was done correctly, you should have a "Example8\dss" and a "Example8\run" directory under the "CalsimDemo" directory. Example8 will be our test system.

Step 2: Investigate the Structure of the Study

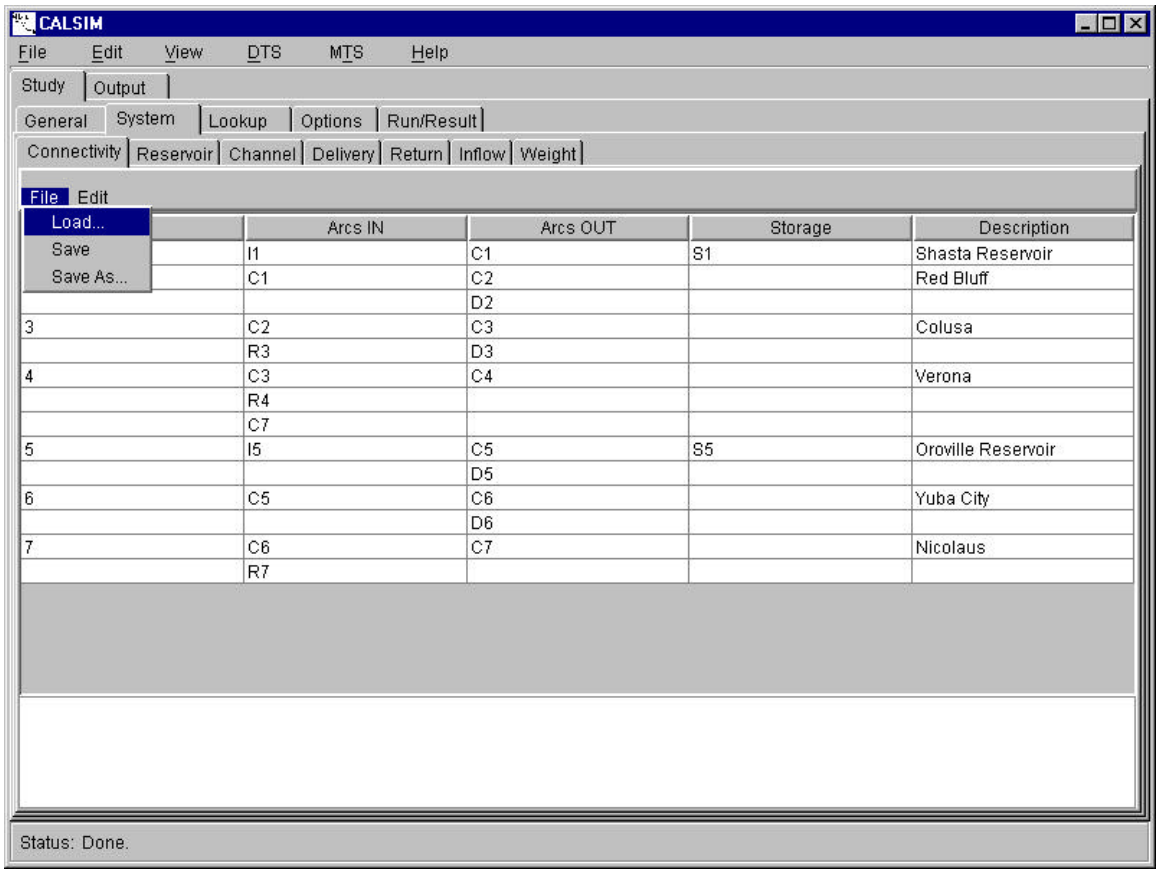
- Using the Windows Explorer investigate the files under the "Example8\dss" folder. The "BigExampleInit.dss" file is in HEC-DSS format and contains the initial conditions for the study. The "BigExampleSv.dss" file, also in HEC-DSS format, contains all timeseries input data (inflows, required minimum flows, demands, etc.).
- Now investigate the files under the "Example8\run" folder. You will find the file "mainEx8.wresl". This file is the main WRESL file containing all operational or system statements and/or pointers to other files containing statements. The "run\System" folder contains a number of "csv" files that will be loaded into the interface to describe the system configuration and basic constraints. The "run\Lookup" folder contains all the relational lookup tables (required and custom) with the extension "table". Other folders exist ("misc" and "wytypes") which contain custom statements representing operational criteria.

Step 3: Open a Study and View the System Configuration

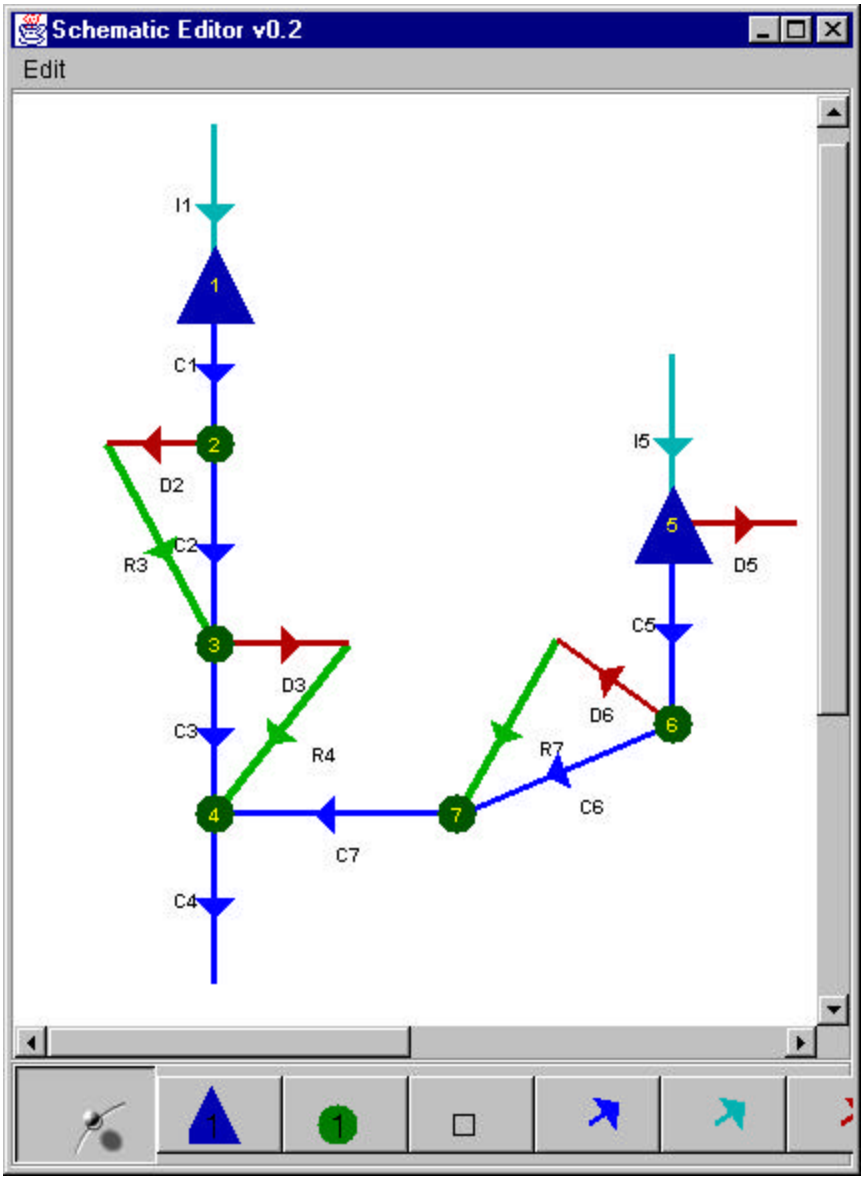
- Using the Start|Programs menu of Windows launch CALSIM1.0. This item was placed here during installation. From the File menu open the study file named “Example8.sty” located in the “Example8” directory. Your screen should appear as shown.



- Switch to the "Study|System" tab. There are seven tables (Connectivity, Reservoir, Channel, Delivery, Return, Inflow and Weight) under this tab that describe the system configuration and basic operational constraints. The configuration can be viewed for the example system by opening the corresponding "Example8\run\system\" csv file (for example, in the Connectivity table use the File|Load menu item located directly above the table to open "Example8\run\system\connectivity-table.csv". Once these files are open, applying File|Save on each table will create the proper WRESL file for the current system.



A graphical representation of the sample system is shown below to assist in interpreting the system tables. Triangles represent storage nodes, circles represent flow-through nodes, D-arcs represent deliveries, C-arcs represent channel flows, I-arcs represent inflows, and R-arcs represent return flows.

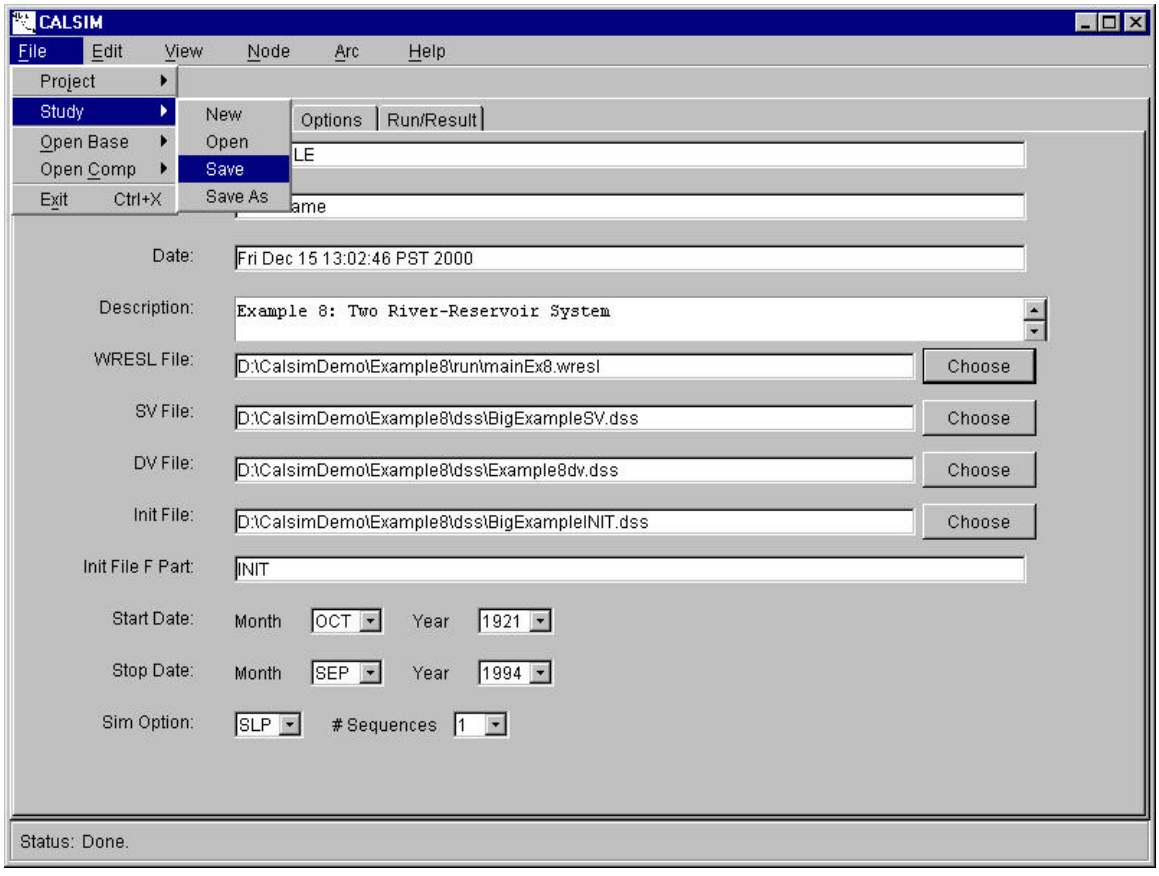


Running a Study

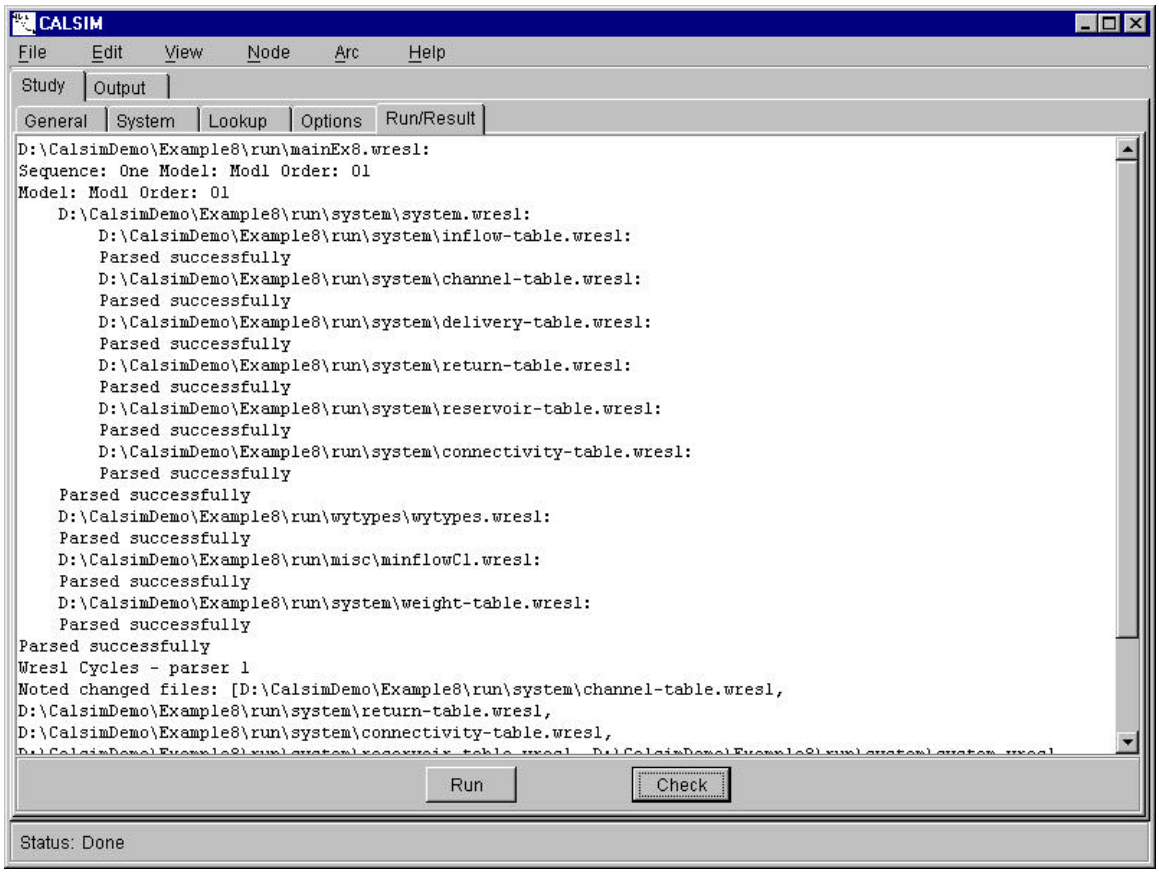
In this section, you will check the syntax of the WRESL statements and run the example study.

Step 4: Check the WRESL Syntax

- Switch back to the Study|General tab and specify the begin date as October 1921 and the end date as September 1994 if it has not already been set. A *study* contains all information set in this Study|General tab. Save this study for future use by performing File|Study|Save. The information will be saved back to the study file which was opened in step 3.



- Switching to the Study|Run tab, press the “Check” button to check the syntax of the all WRESL files included in “mainEx8.wresl”. Results of the syntax check will be displayed on this panel. You should receive the message “Parsing Complete” if the syntax was successful parsed.



Step 5: Run the Sample Study

- If the syntax is successfully parsed, you are now ready to run your study. Press the “Run” button to begin the run. The run consists of the parsing of WRESL statements, the compilation of WRESL statements into Fortran code, and the execution of the compiled model. In the Status bar you should see messages indicating these steps. Once the execution step has begun a small message window will display the time period being simulated and other basic information. Once the execution is completed and is successful, a “Normal Completion”.

Viewing Results

In this brief section, you will prepare basic output of the timeseries results using the CALSIM built-in graphics package (VISTA). Graphs and tables will be created and you

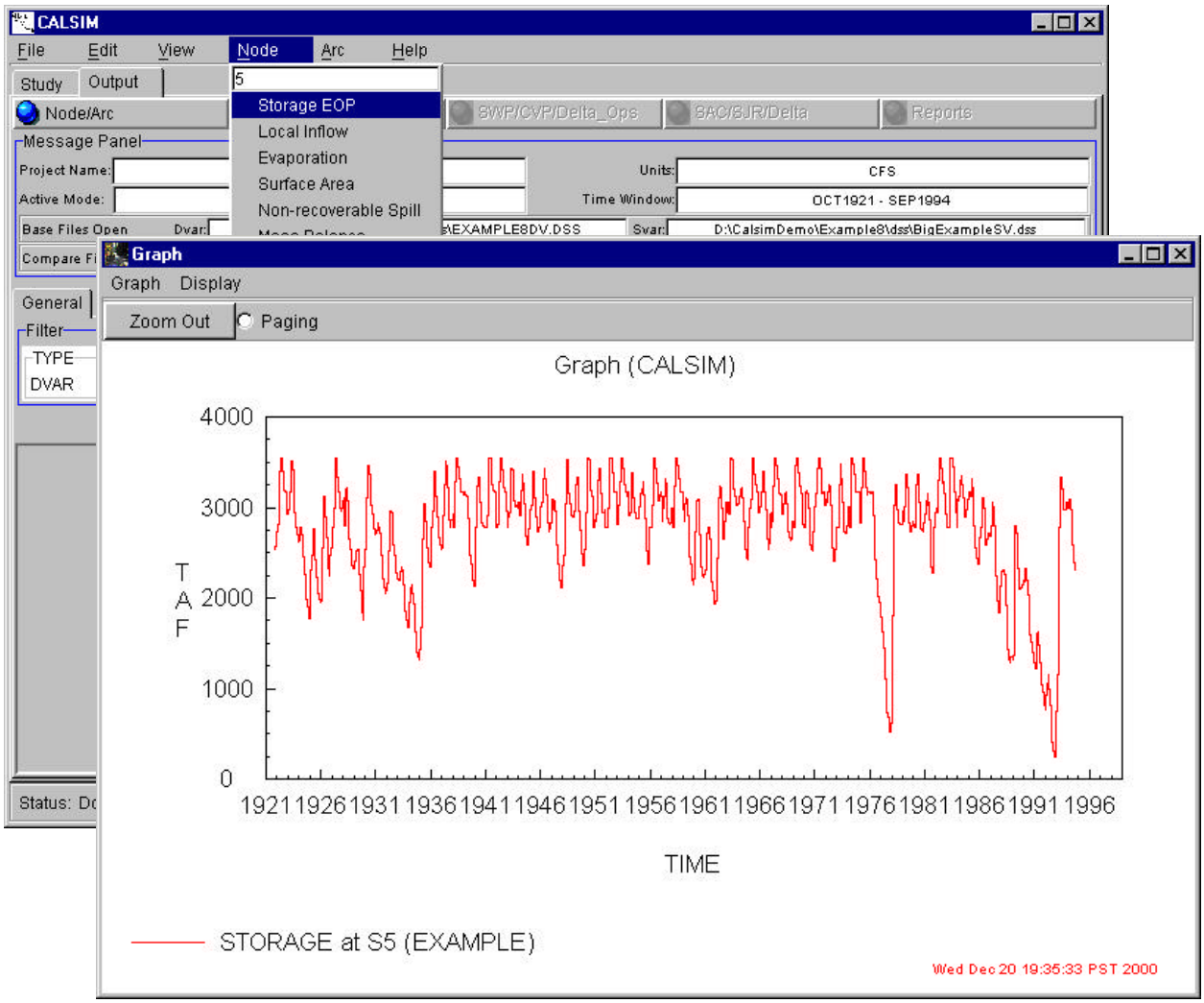
will have a brief introduction to Derived Timeseries creation. Finally, you will learn how save a Project for future use.

Step 6: Opening Timeseries Input and Output Files

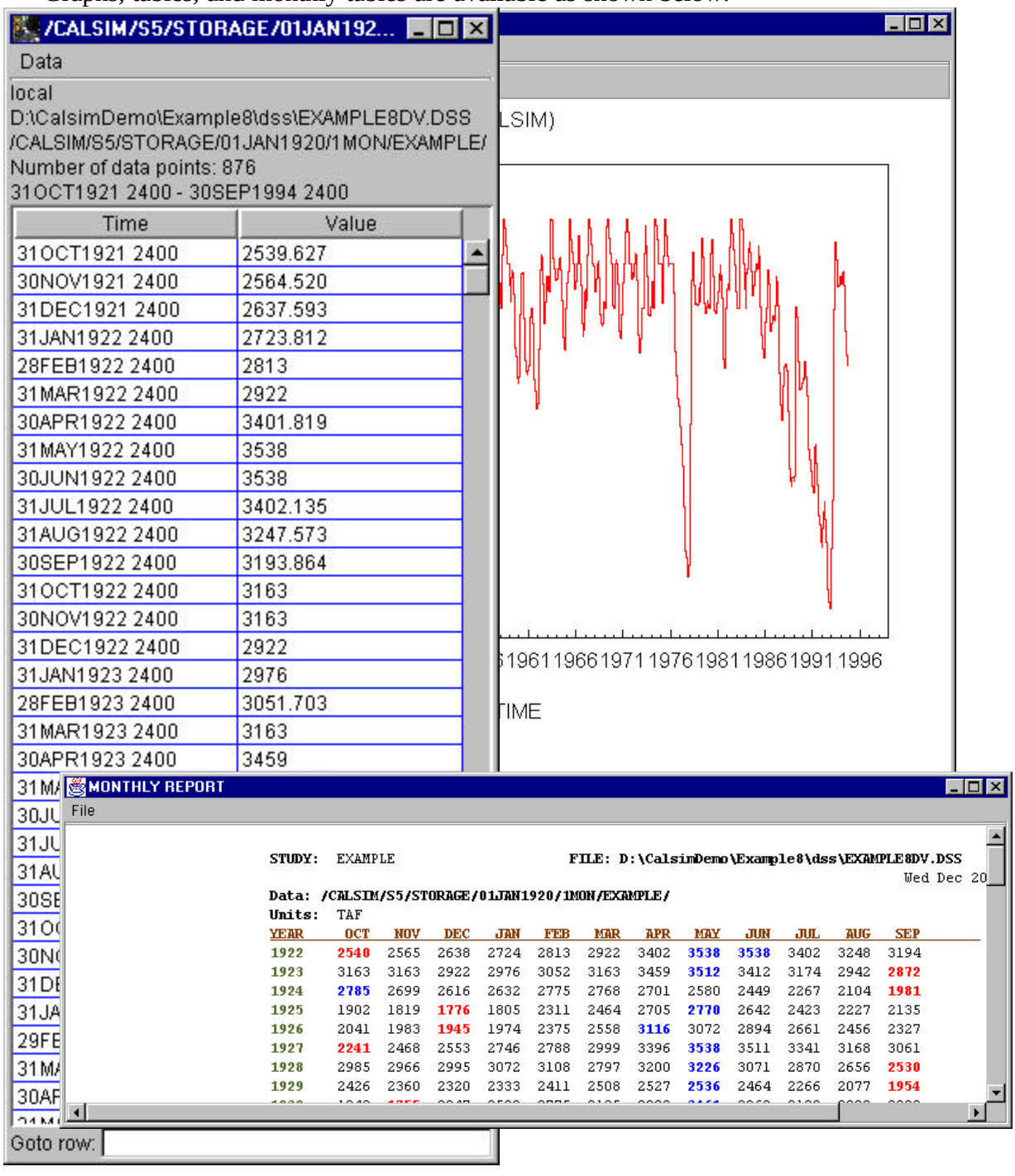
- Switch to the Output tab for viewing all results. From this tab, load the output decision variable file by performing File|OpenBase|DvarFile and selecting the output file used in the model run ("Example8dv.dss"). Similarly, open the input timeseries file through File|OpenBase|SvarFile. The path of these files should appear in message areas of this tab.

Step 7: Creating Graphs and Tables

- Since node 5 represents a storage node, you can access the resulting storage values. Select the Node menu item, enter "5" in the text field, and press "Storage EOP". A display of the resulting storage values should appear. Similarly, the Arc menu allows easy access to arc characteristics.

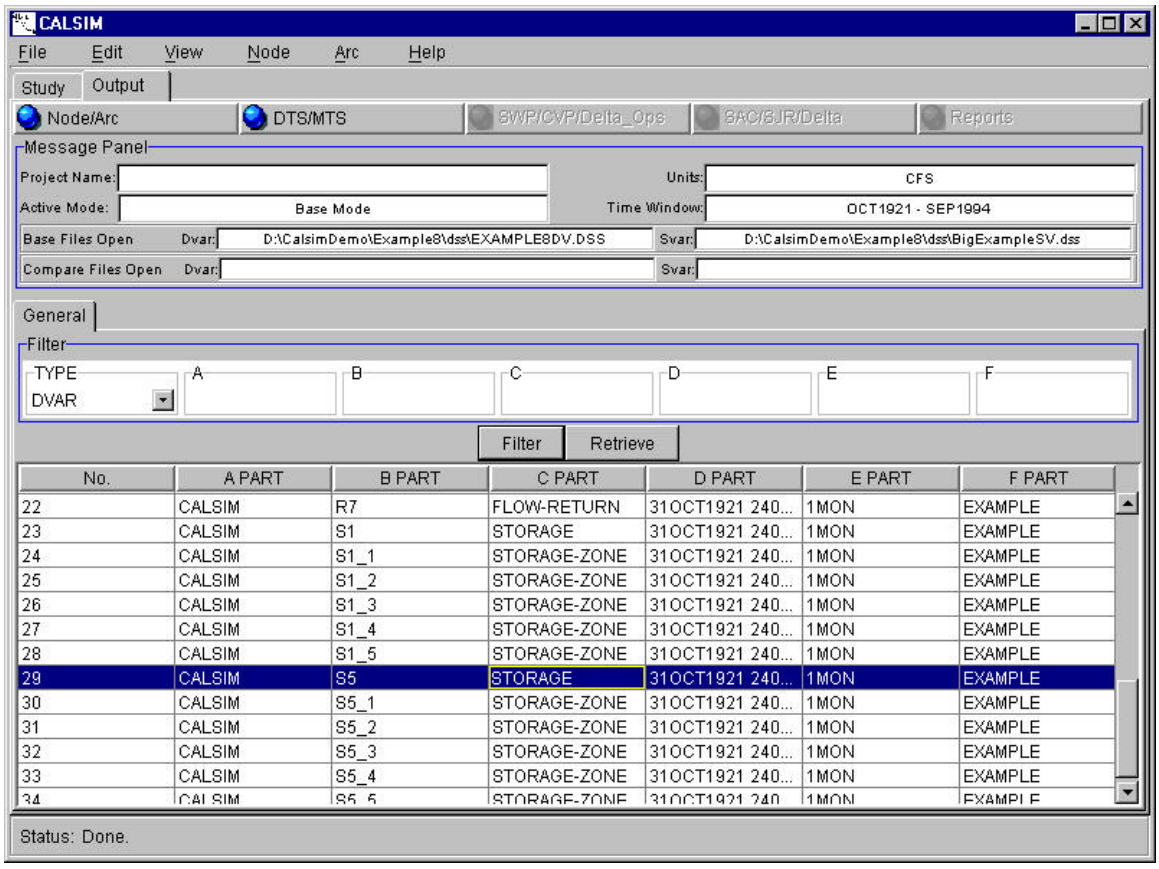


- The view can be modified by selecting one or more options from the View menu. Graphs, tables, and monthly tables are available as shown below.



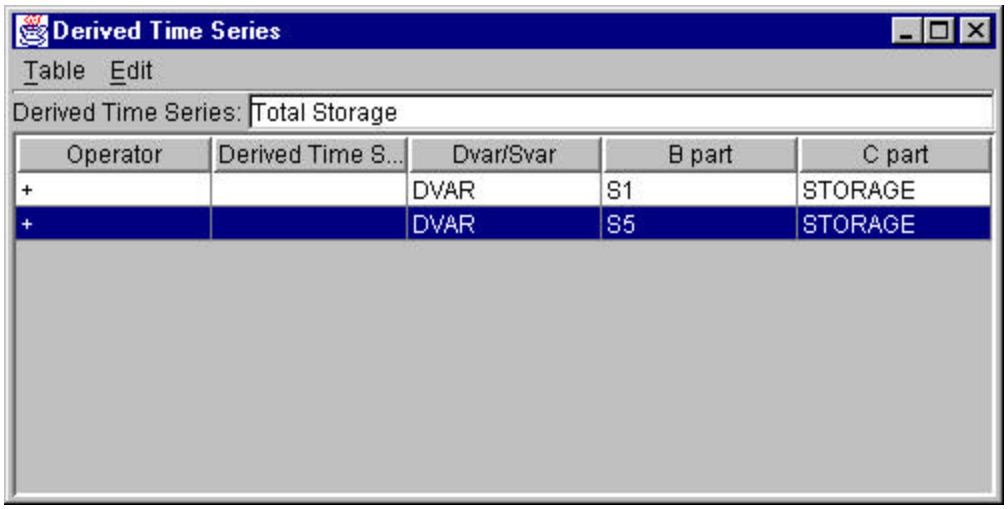
Step 8: General Retrieval of Timeseries Data

- Any timeseries data in a DSS file may be retrieved through the Output|General tab. On this tab, be sure “DVAR” is selected in the type field so that access is directed to the base Dvar file. Press the “Filter” button to list all pathnames available in this file. The storage at node 5 can be displayed by selecting the path “\CALSIM\S5\STORAGE\ \1MON\EXAMPLE\” and once highlighted pressing the “Retrieve” button. Similarly, data can be accessed from “Svar” input file.



Step 9: Creating Derived Timeseries

- In this exercise you will sum the resulting storage values from node 1 and 5. A derived timeseries (DTS) can be created to accomplish this task. Click on the "DTS/MTS" button (with the blue ball icon) to change the upper menu bar.
- Select DTS|New to initiate the creation of a new DTS. Enter "Total Storage" in the derived timeseries name field. Then select Edit|AddRow twice to add two rows to the table. Replace the "?" in the first column with "+" to indicate that a sum is required. Skip the "Derived Time Series" column and be sure that "Dvar" is selected in the "Dvar\Svar" column. In the "B Part" column enter the DSS B-part of the pathanmes ("S1" and "S5"). In the "C Part" column enter "STORAGE" for both variables. Be sure to press enter after editing the cells. Your DTS window should appear as shown below.



- Select the Table|Retrieve menu item to retrieve the graph or table of the resulting math operation. Select the Table|Save menu item to save this mathematical definition in a file or simply quit by selecting Table|Quit. The DTS mathematical definition is automatically stored in the current Project even if you Quit without saving.

Step 10: Saving Work in Projects

- Projects can be viewed as containers for holding your output viewing operations. DSS files opened, DTS and MTS definitions created, viewing options, time window, etc. are all saved as part of the Project. Select File|Project|Save to save this information in a file (extension "prj"). The next time you wish to view similar output you can simply open this Project (File|Project|Open).

Working with CALSIM

This brief section provides additional information for developing CALSIM studies.

Creating the Directory/File Structure

In general each model study should have it's own directory structure. The study name is normally the base directory and a "dss" and "run" directory are created under the base. The "dss" directory will contain the input and output HEC-DSS timeseries files. The "run" directory, as it's name implies, is the location where the model is run. The main WRESL file and diagnostic output is located here. Directories named "system", "lookup", and "external" are created under the "run" directory. The "system" directory contains the system description tables and their generated WRESL files. The "lookup" directory will contain all relational lookup tables (*.table) required for the model run. The "external" directory will contain any external functions (Fortran 90 object files or C++ dynamic link libraries) that are called from the WRESL statements. A typical CALSIM file structure is shown in Figure 3.

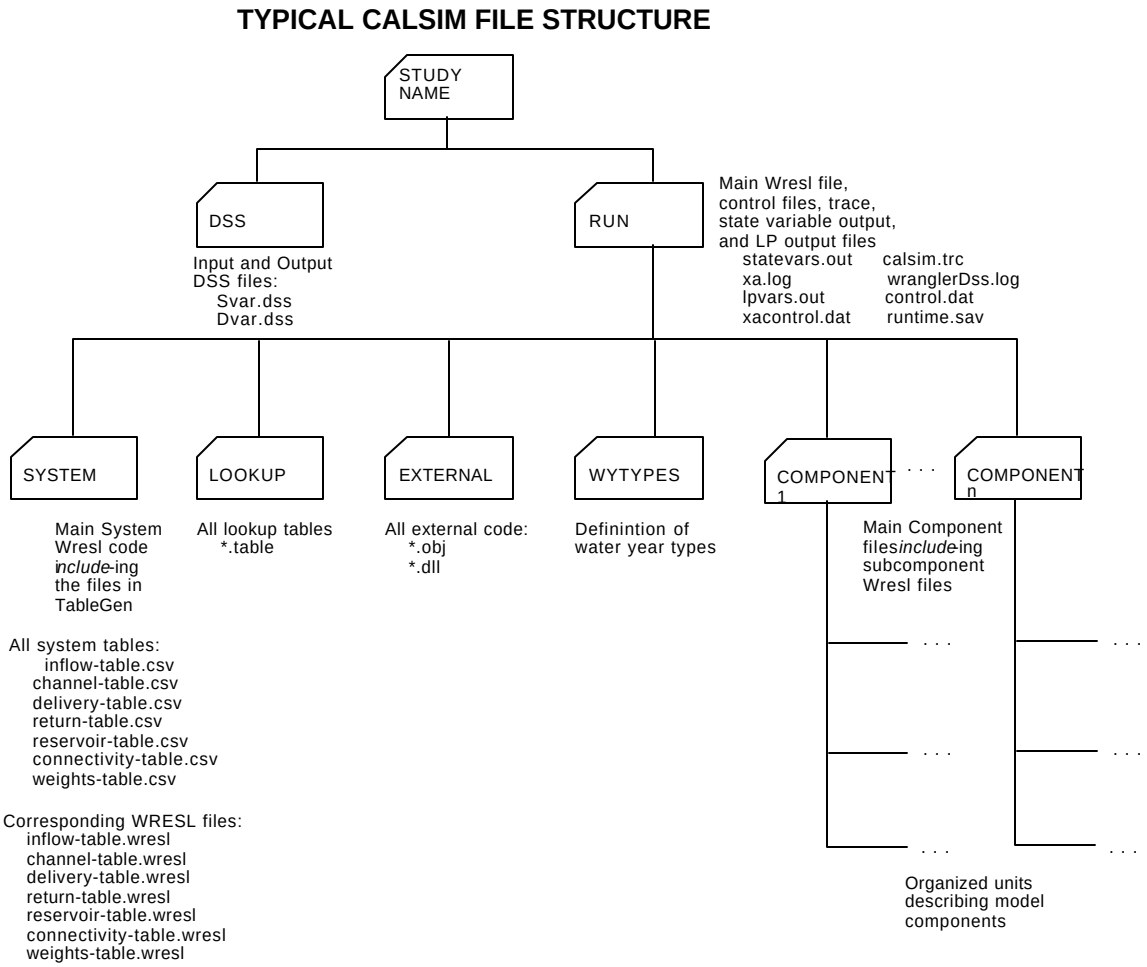


Figure 3. Typical CALSIM File Structure

Creating System Tables

The system tables describe the connectivity of the network, reservoir capacities and operating levels, channel capacities and simple minimum flows, delivery targets, inflows, return flows, and the priority for allocating water among the competing uses. “TIMESERIES”, “LOOKUP”, or “WRESL” may be entered in most of the data fields. “TIMESERIES” implies that the data is located in the timeseries database with a specific pathname. “LOOKUP” means that the data is located in a specific lookup table varying by month only. “WRESL” means that there are WRESL files included elsewhere in the model that specify the data.

Connectivity Table

The network connectivity is described on the basis of nodes and their respective arcs. The first column of the table is the node number, followed by the arcs entering the node (one arc per cell) and arcs leaving the node. The last column is used to describe whether the node has storage and is designated by placing the storage arc name in the fourth cell (i.e. S1).

Reservoir Node Table

Each reservoir node is divided into five zones representing operational volumes. In general the zones are dead pool, lower conservation pool, intermediate conservation pool, upper conservation pool, and flood control pool. The upper levels of each zone are entered into the table as well as the estimated linear evaporation coefficient and the outlet arc. TAF units are assumed in this version.

Channel Arc Table

The channel capacities and minimum flows are specified in this table. For most channel arcs the absolute minimum flow will be zero, but a negative value implies that the flow may occur in two directions. A value in the minimum flow data field will create a split arc, C#_MIF and C#_EXC components, and apply an upper bound of the minimum flow value on the MIF arc. A “NONE” in the minimum flow data field will not cause the arc to be split.

Delivery Arc Table

Delivery arcs are assigned their respective demand values in this table. The demand values are set as the upper bound of the delivery arc. If “WRESL” is specified, the upper bound of the arc **must** be specified in a custom WRESL file.

Inflow Arc Table

Inflow data may be a constant value, or retrieved from the timeseries or relational database. Inflow data are most often of the timeseries type.

Return Flow Arc Table

Return flows in CALSIM are modeled as a fraction of the actual delivery to a particular demand region. The fraction and associated delivery arc are entered in this table to describe the return flow relationship.

Weights Table

The priority for allocating water to competing uses is specified in this table. Each arc, or arc zone, in which water is to be allocated is specified in this table with a corresponding weight. The weight is a measure of the relative allocation priority for consumptive or non-consumptive uses. Storage arc zones are weighted separately to describe the operation rules of a reservoir in concert with upstream and downstream water uses.

Assembling the System WRESL Files

Once all the system tables have been created they should be saved to the "system" directory. When each table is saved to this directory a WRESL file is currently generated which contains the constraint translation. At this point, a file named "system.wresl" should be created in the "run\system" directory and it should *include* all the previously generated system files. For example the "system.wresl" file will contain the following statements,

INCLUDE 'inflow-table.wresl'
INCLUDE 'channel-table.wresl'
INCLUDE 'delivery-table.wresl'
INCLUDE 'return-table.wresl'
INCLUDE 'reservoir-table.wresl'
INCLUDE 'connectivity-table.wresl'
INCLUDE 'weight-table.wresl'

Developing the Main WRESL File

The main WRESL file should simply contain INCLUDE statements pointing to the location of the system and other files that contain statements to be modeled in the current run. The name of this file should be descriptive of the current model as an executable file of the same name will be produced. For the most basic system the main WRESL file contains the following statements.

```
Sequence CycleOne {
        model       mod1
        order       1
}

Model mod1 {
        INCLUDE 'system\system.wresl'
}
```

Timeseries Input File

The timeseries input file must be in HEC-DSS format with the A-part equal to "CALSIM" and the F-part equal to the current study name (i.e. DEMO). The name of the variable declared as "timeseries" in WRESL (i.e. I1) must equal the B-part of data in the input DSS file. This file contains all the timeseries input state variables.

Timeseries Initial Conditions File

The initial conditions required to begin a simulation are also placed in a HEC-DSS file. A timeseries format was chosen, since some variables require several timesteps of previous values to be assigned a current value. In addition, when "position analyses" are performed it is imperative that the current state of the system be initialized for each hydrologic sequence. The pathnames must be the same as that used given in the WRESL variable definition with the exception of the F-part.

Timeseries Output File

The timeseries output file, also in HEC-DSS format, contains all decision variable results. The pathname will be that specified in the decision variable definition, with the F-part equal to the study name. The B-part of all data will be the WRESL variable name. If an existing file is specified as the output file, the data will be overwritten for the time period of simulation. If this file does not exist, a new file will be created.

Lookup Tables

Relational data is stored in text files located in the "study\run\lookup" directory. These files must have extension *.table*. Up to five comment lines (use "!") may be added to the top of the file. The first non-comment line must contain the name of the table as specified in WRESL *select from* statements and must also match the name of the file (less the extension .table). The line following the name of the table contains the field names to be searched (i.e. year_type, month, etc). Below this line is the data associated with each field and must only contain numeric values. Improvements to the lookup table will be performed in future versions.

Running a Study

The CALSIM application is invoked from the desktop icon or the button in Start|Programs.
A study contains all the information currently stored in the Study|General panel of the user-interface. The Study|General panel currently contains the general information required for the simulation. The required fields are listed below:

Name	-	must match the DSS F-part of the input\output files (ie. DEMO or 1995DO9E-CALFED-771)
WRESL File	-	main WRESL file containing all system constraints (no "-" in the directory or file name)
Svar DSS File	-	input DSS file (State variable data)
Dvar DSS File	-	output DSS file (Decision variable information)
Init DSS File		initial conditions DSS file (ie. initial storage values)
Init File F-part		F-part of init DSS file

The Run tab console window will contain any WRESL syntax errors and a listing of the messages produced during model creation. To check the syntax of all the included WRESL files press the “Check” button in any panel. Errors or a message of successful parse will be shown in the Run tab. To run the model (parse-compile-execute) press the “Run” button. The files will be parsed and interpreted into the Fortran 90 language, which in turn is compiled and executed. A “CALSIM Execution” and “XA Message Window” will appear after compilation with runtime information. The intermediate Fortran 90 file is not available to the user. However, an executable file is created that contains all the logic of the model run. This file is invoked by the user-interface if no changes have been made to the WRESL files. To stop the execution before it is complete, close the “CALSIM Execution” message window (this will be improved upon).

Diagnostic Output Files

Upon completion (successful or unsuccessful) of a model run, several diagnostic output files are produced in the directory in which the run was initiated. Some are useful (xa.log and statevars.out) and some are useful only to the model developer (calsim.trc). All of the files are written as text files and may be viewed.

XA.LOG:	“XA” solver output
STATEVARS.OUT:	State variable values
LPVARS.OUT:	CALSIM created slack and surplus variable values
WRANGLERDSS.LOG:	Log of data passed to and from DSS files
CALSIM.TRC:	Trace file for internal subroutines

Viewing Results

Results may be viewed by switching to the Output tab of the user-interface and opening the appropriate decision variable and state variable DSS files. Output may be viewed in various formats and comparisons can be performed across studies. A tutorial will be included in future versions to assist in becoming familiar with the output options.