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SPIDA - Analysis of Looped Networks

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INTRODUCTION

SPIDA is the Interactive Program for Interactive Drainage Analysis. It is an extra component of the Wallingford Procedure for analysis of looped drainage systems with flat gradients. SPIDA is not exactly new either. It has been around in some form for about three years and has been used for projects in Bangkok. What is new is that it has been made suitable for pipe systems which have low dry weather flows and which have significant gradients.

It is not a replacement for WALLRUS, but an alternative for systems that WALLRUS is unable to analyse. It is more complex and slower than WALLRUS and requires a more powerful micro computer or workstation to run it. It is therefore unlikely to be used where WALLRUS is adequate.

SPIDA is designed to be as compatible as possible with WALLRUS so that they can be used together. However there are large differences in the definition of the sewerage system data. It is generally similar to the WALLRUS simulation program in that it includes rainfall runoff, dry weather and other inflows and routing of flows through pipes, channels and ancillary structures.

RAINFALL RUNOFF

SPIDA uses the same rainfall files as WALLRUS, although it includes the ability to run multiple events from one data file. This is described in the WALLRUS manual but was never implemented in the program. SPIDA uses spatially varied rainfall from nine different raingauges in the same way as WALLRUS, but in future this could be extended to allow even more gauges.

The default rainfall runoff model is the standard UK model as used in WALLRUS. However SPIDA is more flexible in the use of other rainfall runoff models. Instead of having a limited set of predefined surface types to choose from, the user can define extra surface types using fixed runoff coefficients, modified versions of the UK model or the Soil Conservation Service model. This gives more flexibility to define the appropriate surfaces, and the program includes facilities for editing the surface definitions. However, as with WALLRUS we still recommend the use of the standard UK model in this country.

We also have a version of SPIDA with the new runoff model which John Packman reported on at the Spring meetings. This will be incorporated into the standard version in the near future.

OTHER INFLOWS

The formats of the dry weather flow, inflow hydrograph and level hydrograph files are also the same as WALLRUS. As for the rainfall data, these files can now contain multiple events. The files now also have a field for the start date and time of the event, and the program will synchronise all of the input files to the start date and time of the simulation. The output hydrographs also use this same format in the same way as WALLRUS. This means that the results from one program can be used as input to the other without difficulty. Also included in the package is the program FOUL which was developed for MOSQITO which creates standard files for the diurnal variation of dry weather flow, and simplifies the setting up of catchment specific dry weather flow files.

PIPE AND CHANNEL FLOWS

SPIDA includes the same range of pipe and channel shapes as the latest versions of WALLRUS. This includes many more shapes than WASSP did. It also has the facility to give separate hydraulic roughness values for the invert and soffit of pipes to allow for sliming and sediment deposits.

The method of calculating the flow through the pipes and channels is very different from WALLRUS, and this allows it to cope with flat and looped systems. WALLRUS has three different methods of calculating flows:

Normal free surface flows
: This uses Muskingum Cunge routing working down from the top of the system to the outfall.

Surcharge flow
: This uses a simultaneous solution of the pressurised flow equations at a 1 second timestep.

Free surface backwater
: This uses a double sweep of discharges and levels.

SPIDA has only one method which copes with all of these situations. This avoids many of the problems of instability during transition from one to another. The method includes the momentum terms which are required for surcharged flow and the backwater term which is normally dropped in WALLRUS. A simultaneous solution of the equations is used for all flow conditions. All pipes include free surface backwater effects including reverse flows under free surface conditions which WALLRUS cannot handle.

Because the method can cope with all of these effects it is necessary to iterate to ensure a stable solution at each timestep. Because of

this and the simultaneous solution of the calculations for the whole system the calculations are very slow. To speed this up as much as possible SPIDA uses a variable timestep to allow for quicker calculations when flows are changing only slowly. This works by setting a target timestep for the analysis, typically 60 seconds. If the flows are varying rapidly so that the calculations require more than five iterations to converge to a solution, then the timestep is progressively halved until the convergence is achieved. When the flows become steadier and the number of iterations reduces, then the timestep is increased again towards the target. This automatically allows for the shorter timestep required for rapidly varying flows in surcharge.

ANCILLARIES

The modelling of ancillaries is much more flexible than that in WALLRUS. Ancillary structures are built up of individual components to represent storage volumes and flow controls. Ancillaries with multiple tanks connected by any number of flow controls can be defined. This can be used for double overflows, off line tanks, or pumping stations with separate dry weather and storm pump wells. Any pipe can have reverse flow under any conditions there is no longer any difficulty with reverse flows over overflows. This also means that bifurcations can be modelled correctly with both pipes at the same level.

DATA STRUCTURE

The data structure of SPIDA is very different from that of WALLRUS, and it will be necessary to change data files to move models to SPIDA.

WALLRUS has one line of data to define a sub-catchment, the manhole that it drains to and the pipe downstream of it. SPIDA divides this into two to be more compatible with standard sewer records.

One line of data defines the sub-catchment, and the manhole that it drains to. This is given a label which can be an STC25 manhole number. The sub-catchment data includes three surface types (road, roof and pervious) which can be defined either as areas in hectares or as percentages of the total area.

Extra data can be given to define the storage volume in the manhole as two different plan areas at different levels. The floodable are of the catchment can also be defined to change with flood depth.

A separate lines of data is used to define pipes or channels. These are given a label which is similar to an STC25 sewer reference. The data for a sewer includes the length, size, shape, roughness and invert levels. The data also includes the headloss index for each end of the sewer.

Flow controls for use in ancillaries are defined on separate lines of data which gives the type of control and all of the data to describe its behaviour.

USING THE PROGRAM

The SPIDA package includes ancillary programs for preparing the data and displaying results in a similar manner to those for WALLRUS. However there is much less use of the standard editor to create files.

The sewerage system data is entered into a program which combines the functions of an editor and the error checking and pre-processing of the Simulation Part 1 of WALLRUS. This automatically puts in default values for any fields that the user leaves blank, and carries out a lot of checking for errors as each value is entered. This should make it much simpler to get the data correct first time.

The FOUL program can be used to generate standard dry weather flow files without having to edit them directly.

An editor is provided for other files which is an improvement on the exiting WALLRUS editor.

For experienced users it is still possible to create all of the data files using their own editor, but as the facilities of the data entry programs improve we hope to persuade even these that there are advantages in letting the computer do more of the work.

THE BAD NEWS

There are, of course, some disadvantages to using SPIDA. The main one is that it is much slower than WALLRUS, and requires a lot more memory. A version to run on a standard PC would therefore have a capacity of only 100 pipes.

The other disadvantage is that it can be difficult to use. Although it has overcome some of the causes of instability that WALLRUS suffers from it has also introduced others, particularly at low flows. When SPIDA suffers instabilities it does not carry on and produce an oscillating output, it just stops. IT can therefore be very frustrating finding out what has gone wrong and how to put it right.

However when WALLRUS has already given up, SPIDA may be your answer.