SPIDA - APPLICATIONS GREAT AND SMALL
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1.0 Introduction

1.01 This presentation describes applications of Wallingford Software's Simulation Program for Interactive Drainage Analysis - SPIDA run on an IBM 486 Micro-Computer.

1.02 Three separate studies are considered which demonstrate the wide range of possible applications of SPIDA. In each case, the SPIDA package has been used following unsuccessful attempts to carry out the modelling work using either WASSP or WALLRUS. Direct comparisons between the modelling packages can therefore be made.

2.0 Driffield Sewerage Investigation

2.01 Driffield is a market town in East Yorkshire with a population of approximately eleven thousand. The catchment is fairly flat and covers an area of some 160 hectares. Two unusual features of this sewerage system are:-

(1) There is a high concentration of Combined Sewage Overflows (CSOs) within the central area of the town all of which discharge to a small watercourse called The Beck.

(2) The sewers in the town follow a grid pattern resulting in a large number of loops in the system.

2.02 The main objective of the investigation was to assess the performance of the eleven CSOs in the system. Following this sewerage rehabilitation options are to be developed to meet the discharge consents stipulated by the National Rivers Authority (NRA).

2.03 The sewerage system of Driffield was previously modelled in 1986 using the Wallingford Storm Sewage Package (WASSP). However, it was found that, using WASSP, accurate simulation of flows in the central looped portion of the sewerage system could not be achieved. This was partly due to the limit on the number of pipes lengths and ancillaries that could be included in a Micro-WASSP model; of the twenty seven bifurcations that were known to exist in the system, only ten were included in the model. In addition another major contributing factor was that the software could not model reverse flows through the secondary continuation pipe at bifurcations. In dendritic sewer systems this is not generally a consideration, however, at Driffield, the direction of flow is likely to reverse in the central looped portion of the system because of rising water levels and slack gradients. For this reason it was concluded that an accurate assessment of the CSOs could not been made using WASSP.

2.04 Early in 1991 Wallingford Software provided the Babtie Group with a pre-release version of SPIDA. The remodelling and verification of the sewer system using SPIDA was completed in December 1991. All twenty seven of the bifurcations were modelled together with almost twice the number of sewer lengths that had been included in the WASSP model. The simulation of complex flow conditions in the central looped area of the sewerage system was proven by verification of the SPIDA model using recorded flow survey data. The frequency of operation of each of the eleven CSOs together with the spill volumes could now be assessed.

2.05 Time Series Rainfall (TSR) was used to predict the frequency of operation of each CSO. One CSO was found to operate during all ninety nine TSR events whilst another did not operate at all. The remaining nine CSOs were found to operate between twenty and forty times a year. These results were confirmed by site observations and during the flow survey,flow recorders were installed at seven of the eleven CSOs.

2.06 The SPIDA model is now verified and is being used as a design tool for the development of rehabilitation options. It has been concluded that SPIDA will accurately simulate complex flow conditions in systems such as Driffield's. This would not have been possible using WASSP or WALLRUS. However, it should no noted that the majority of sewer systems in the UK are dendritic with steeper pipe gradients than those encountered at Driffield. In such cases WALLRUS is considered to be a more suitable modelling tool. Run times using SPIDA do increase significantly when steep pipes are modelled so the best overall modelling strategy for a sewerage system may well involve using WALLRUS to model the majority of a system, with SPIDA being used to examine discrete elements where flow conditions are known to be complex as described in Section 3.0.

3.0 Use of SPIDA on a Complex Element of a WALLRUS Model

3.01 The second case study examines the use of SPIDA to examine complex flow conditions in a small section of a WALLRUS model.

3.02 A coastal town of some 60,000 population was modelled using WALLRUS. The

WALLRUS model was successfully verified throughout the majority of the system which was dendritic with a high frequency of steep pipes. However, problems were encountered with a 800m long large diameter transfer sewer which conveys flows from the town to the treatment works. At each end of this length of sewer there are CSOs which discharge into the sea. It was known from site observations that the dowstream CSOs was affected by reverse flows from the sea during high tide conditions. This in turn was causing backing up of flow along the transfer sewer up to the higher of the two CSOs. This flow condition was not being simulated using WALLRUS because reverse flows through the secondary (overflow) pipe of the downstream CSO could not be modelled. The simple process of modelling this part of the sewer system using SPIDA was carried out and the flow conditions predicted by the model were confirmed by flow survey information. The spill volumes predicted by SPIDA were used to determine storage at the CSOs to reduce discharges to within limits stipulated by the NRA.

3.03 This SPIDA modelling exercise was carried out in one afternoon. This example illustrates an important application of SPIDA. Its use on a small element of the system has provided information that may form the basis of a major part of the rehabilitation of the system. It is concluded therefore that the use of SPIDA in conjunction with WALLRUS will often provide the best results in the analysis of sewer systems both in the UK and overseas.

4.0 Use of SPIDA to Assess Steady State Flow Conditions in a Large Aqueduct

4.01 The system being investigated comprises a 2.0m diameter aqueduct 3000m in length which transfers water between two reservoirs. The aqueduct passes beneath a road and at this point its level drops and rises again after the obstruction thus forming a syphon type structure. This simple system had been modelled using WALLRUS and it was found that, despite a steady state inflow to the system, stable flow conditions could not be achieved. The exercise was then repeated using SPIDA and this time steady state conditions which correlated with field observations were achieved. This was due to the SPIDA initialisation programme which is designed specifically to stabilise initial steady state flow conditions.

4.02 Whilst this is not likely to be a major application of the SPIDA package, it does demonstrate that SPIDA can be used with minimal time input to investigate a wide range of flow conditions.

5.0 Conclusion

5.01 This paper has described three contrasting applications of the SPIDA package. The

Driffield Study was an example of the use of SPIDA to model an entire catchment. This was a good opportunity to demonstrate the robustness of the package. This is considered to be an unusual case, however as steep pipe gradients in dendritic sewer systems should be modelled using WALLRUS.

5.02 The second case study demonstrates an important application of SPIDA; its use to examine a specific element of a large sewer system which had otherwise been successfully modelled using WALLRUS.

5.03 The third case study has been included to demonstrate that SPIDA can be used in situations which are not mainstream sewer modelling studies.

5.04 SPIDA is an important development in sewer modelling technology. Its application permits accurate simulation of complex flow conditions in flat looped systems where flows are likely to reverse. Successful modelling of the majority of large sewer systems should be possible using the WALLRUS and SPIDA packages as appropriate.

2.1 SPIDA Applications Great and Small **N.P.Sanders (Babtie Shaw and Morton)**

Question

Timothy Webster Severn Trent Water

What were the problems with SPIDA and it's limitations? Are the hydrography different, and were backwater flags used in WALLRUS to get it to perform better ?

Answer

The major limitation of SPIDA is that occaisionally the software has problems with steep pipe gradients. These are likely to significantly increase run times or may even cause the programme to fail to reach a solution and stop during simulation.the problem in steep catchments must be weighed against the advantages in flat looped systems.

More data was needed in SPIDA model as all the minor pipe loops had to be put in. The hydrography are output in the same manner to WALLRUS and are of a similar format, SPIDA HYQ files can be read by WALLRUS and vice versa.In Case Study 2 backwater flags were used in WALLRUS but this still did not allow accurate simulation of the flows in the small area of the system that was the successfully modelled using SPIDA.

Question

David Wright Consultant

Verification in WALLRUS is relatively straight forward what are the differences and complexities required in SPIDA.

Answer

The original flow survey for the WASSP modelling study of Driffield in 1986 was not sufficient for verifying the SPIDA model and a second flow survey was carried out in 1991. In the revised flow survey the monitors were located at 7 of the 11 SWO's to measure complex flow conditions such as flow reversal and SWO operation.Verification at these locations was important to ensure that the SPIDA model could be used with confidence as a design tool for the rehabilitation of overflows. Using SPIDA accurate verification of the complex flow conditions in the vicinity of the SWO's was achieved. This would not have been possible using WASP and while SPIDA is capable of modelling more complex flow conditions it is not envisaged that verification will be more difficult to achieve. It should be noted that for a SPIDA modelling study flow monitors should be placed both in major sewers (as in WASSP and WALLRUS studies) and also in smaller pipes such as overflow pipes where important flow conditions are expected to occur.

Question Graham Squibbs North West Water

SPIDA appeared good on discharge but how did it perform on depth ?

Answer

The SPIDA model of Driffield verified well on both discharge and depth. This was very important because of the large number of SWO's in this flat sewer system the simulation of which depended on accurate prediction of depth in order that the correct spill frequency and volume could be modelled. SPIDA was particularly good when going into surcharge a point at which WALLRUS sometimes becomes unstable.

Comment

Bob Armstrong Watson Hawksley

In investigations of looped systems that were impossible to fully represent in WALLRUS the WALLRUS verification was poor in area of the loops although good in the more dendritic parts. When the model was converted to SPIDA and the system fully represented good verification was immediately obtained in those areas where they could not be obtained with WALLRUS. SPIDA had also produced better depth plots than WALLRUS in area where both SPIDA and WALLRUS gave good agreement on flow.

NPS said SPIDA models were easier to add to and develop as the pipes do not have to be in a strict order, this is because of the Node and Link file method in the DSD files.